OTEC
373.190971 3
059DE/C-Ph

55 Ont.

Curriculum Guideline

Science

Intermediate and Senior Divisions

1987

Part Eight: Applied Physics, Grade 12, General Level

Technological Science, Grade 12, General Level

DRAFT

CONFIDENTIAL

December 1986

THE LIBRARY

The Ontario Institute

for Studies in Education

Toronto, Canada

Contents

Introduction 1

The Parts of the Guideline 1
Features That Apply Across the Science Program 4
The Science Curriclum Continuum 5
Compulsory and Prerequisite Courses 6
Curriculum Emphases 7
Student Activities 7
Sensitive Issues 8
Evaluation of Student Achievement 9
Cross References 9

Particular Features of the Grade 12, Applied Physics Course 10

Applied Physics, Grade 12, General Level (SPA 4G) 13

Core Units:

1. Sound 14
2. Light and Colour 21
3. Heat 29
4. Electrical Energy 37
5. Motion 44

Optional Units:

1. Fluids 51
2. Nuclear Energy 59
3. Properties of Solids 65
4. Time 71
5. Distance: Measurement and Application 76
6. Locally Designed Unit 81

Particular Features of the Grade 12, Technological Science Course 82

Technological Science, Grade 12, General Level (STE 4G) 85

Core Units:

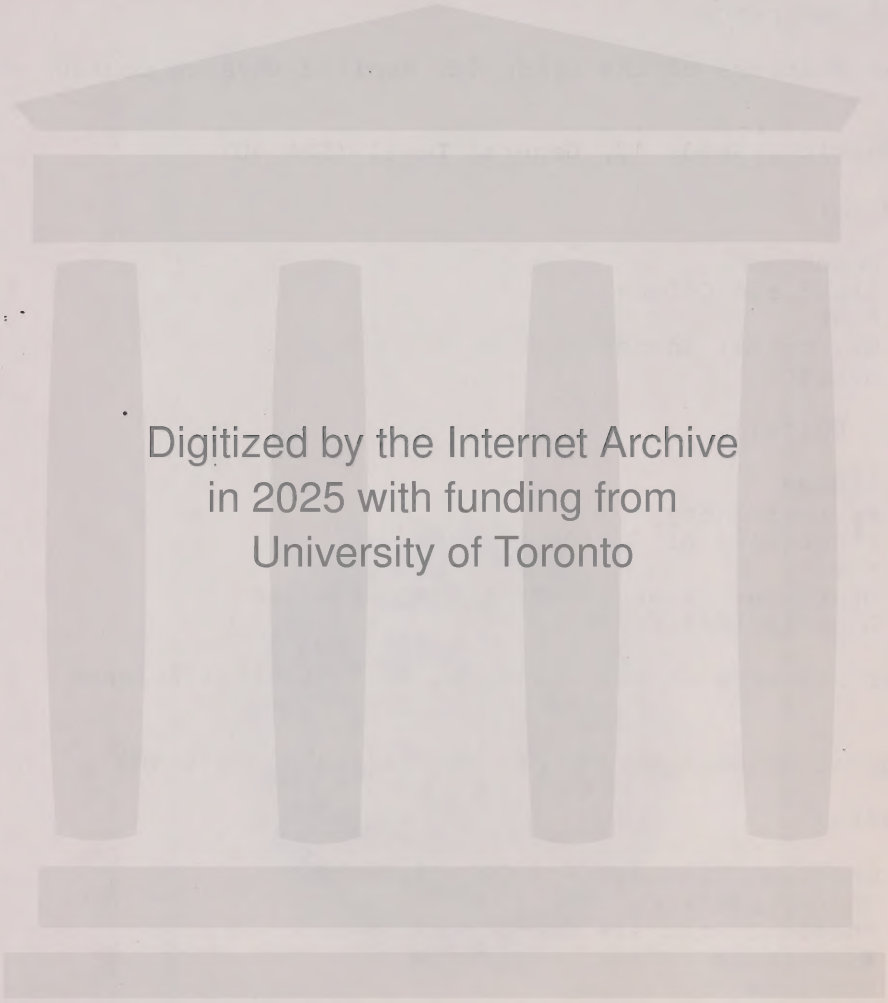
1. Chemical Language and Calculations 86
2. Thermochemistry 92
3. Chemical Analysis 99
4. Kinematics 105
5. Kinetics 111
6. Statics 116
7. Fluids 121
8. Machines 129

Optional Units:

1. Materials 134
2. Locally Designed Unit 141

Appendix A: The Table of Contents of Part 1 142

Appendix B: Science Courses and Their Course Codes 144



Digitized by the Internet Archive
in 2025 with funding from
University of Toronto

https://archive.org/details/curriculumguidel00onta_37

Introduction

The Parts of the Guideline

This document is Part 8 of a fifteen-part curriculum guideline that outlines the science program for the Intermediate and Senior Divisions in Ontario schools and describes the science courses that can be offered. The term guideline refers to the entire set of fifteen parts.

This part must be read and implemented in conjunction with Part 1, "Science Program and Policy". When implementing the courses that are described in this document, teachers are to incorporate the many features outlined in Part 1, which will enable them to interpret the overall intent and expectations of the Ministry of Education in the science program. The table of contents for Part 1 is given in Appendix A at the end of this document so that the reader may have ready access to the list of chapters and topics therein.

The provincial science program for the Intermediate and Senior Divisions comprises the courses described in Parts 2 to 15, and these come under the framework and policy set forth in Part 1. The entire science guideline consists of the following fifteen parts:

Part 1: Science Program and Policy

Part 2: Science, Grades 7 and 8

Part 3: Science, Grades 9 and 10, General Level

Part 4: Science, Grades 9 and 10, Advanced Level

Part 5: Science, Grades 9 and 10, Basic Level

Part 6: Science, Grades 11 and 12, Basic Level

Part 7: Applied Biology, Grade 11, General Level

Applied Chemistry, Grade 11, General Level

Part 8: Applied Physics, Grade 12, General Level

Technological Science, Grade 12, General Level

Part 9: Biology, Grade 11, Advanced Level

Biology, Ontario Academic Course

Part 10: Chemistry, Grade 11, Advanced Level

Chemistry, Ontario Academic Course

Part 11: Physics, Grade 12, Advanced Level

Physics, Ontario Academic Course

Part 12: Environmental Science, Grades 10 to 12, General Level

Part 13: Environmental Science, Grades 10 and 12, Advanced Level

Part 14: Geology, Grade 12, Advanced Level

Part 15: Science in Society, Ontario Academic Course

Note: A list of the science courses with their course codes is given in Appendix B.

Table 12 Authorized Science Guideline Courses, Intermediate and Senior Divisions

Grade 7	Science		
Grade 8	Science		
	Basic Level	General Level	Advanced Level
Grade 9	Science (SNC 1B)	Science (SNC 1G)	Science (SNC 1A)
Grade 10	Science (SNC 2B)	Science (SNC 2G)	Science (SNC 2A)
		Environmental Science (SEN 2G)	Environmental Science (SEN 2A)
Grade 11	Science (SNC 3B)	Applied Biology (SBA 3G)	Biology (SBI 3A)
		Applied Chemistry (SCA 3G)	Chemistry (SCH 3A)
		Environmental Science (SEN 3G)	
Grade 12	Science (SNC 4B)	Applied Physics (SPA 4G)	Environmental Science (SEN 4A)
		Environmental Science (SEN 4G)	Geology (SGE 4A)
		Technological Science (STE 4G)	Physics (SPH 4A)
OAC			Biology (SBI OA)
			Chemistry (SCH OA)
			Physics (SPH OA)
			Science in Society (SSO OA)

Any one of these

Note: Prerequisites to the OACs are shown by arrows.

Features That Apply Across the Science Program

Part 1 of the guideline specifies a great number of features that are to be integrated into the design of the science program in the Intermediate and Senior Divisions. There are too many of these features to describe in full in each of parts 2-15, but the following will give the reader some idea of the kinds of features that are described. They include:

- the identification of the science courses that are mandatory towards the earning of the Ontario Secondary School Diploma;
- the list of science courses that are prerequisite to other science courses;
- the policy regarding mandatory student activities in the science laboratory;
- the list of aims of the science curriculum and the various emphases that may be used to blend such aims with scientific content;
- policy governing time allocations for units of study and the order in which core and optional units may be taught;
- stipulations about locally designed units;
- suggestions about preferred routes that students might take through the science program in a secondary school;
- policy regarding the introduction of non-guideline courses, which are subject to approval by the Ministry of Education;
- recommendations related to exceptional students, individualized instruction, life-management skills, career awareness, the role and evaluation of language in science courses, and a balanced perspective on the role of both girls and boys in science;
- the introduction and handling of sensitive issues;
- specific suggestions about resources for the teaching of science;

- ideas about different modes of delivering science courses including the co-operative education mode;
- the significant role to be played by measurement and metric units in science courses;
- stipulations related to the treatment of symbols, significant digits, and mathematical problem solving;
- the roles of calculators and computers in science courses;
- specific directions about safety;
- policy and principles pertaining to the evaluation of student achievement;
- differences in the treatment of science courses at the three levels of difficulty;
- many suggestions about implementing the science program.

It cannot be emphasized strongly enough that teachers of science must integrate the policy and recommendations outlined in part 1 with the teaching of science and cannot simply rely on the course descriptions given in parts 2-15 of the guideline.

The Science Curriculum Continuum

By the time students have reached the Senior Division, they will have experienced an unified approach to science with a number of other subject areas in the Primary and Junior Divisions, and then an diversified approach to a mosaic of science disciplines - biology, chemistry, physics, and environmental science - in the Intermediate Division. In the Senior Division, they are provided with a specialization approach where the science courses deal with a single discipline at a time.

Although these approaches - integration, exploration, and specialization - provide different ways of dealing with the subject, the intention is to ensure that there is a continuum throughout the years. The applied physics and technological science courses in this document build on the physics and chemistry units of the general level courses in the Intermediate years.

For many students enrolled in general-level senior science, particularly those who intend to take technological studies at the colleges of applied arts and technology, it is recommended that they consider including in their secondary school program applied chemistry, applied physics, and technological science.

Teachers should not only be aware of the subject matter contained in the physical science units of the Intermediate Division courses but also be aware of how the Appplied Physics, Applied Chemistry, and the Technological Science courses relate to each other.

In all science courses the core units and the prescribed number of optional units, if any, are to be included. The time allocation for each unit of study should act as a guide in helping teachers devote a proportionate amount of time to each of the units in a course. This is important in view of the continuum from one course to another and to post-secondary science programs.

Compulsory and Prerequisite Courses

In the secondary school program two science courses are required among the compulsory subjects that are necessary for the earning of the Ontario Secondary School Diploma. The senior level Applied

Physics and Technological Science courses build upon the content and concepts found in the grade 9 and 10 general-level science courses, and it is therefore highly recommended that these courses be taken prior to taking the Senior Division courses.

Curriculum Emphases

It is recommended that teachers organize each of the courses described in this document around a particular curriculum emphasis or set of emphases. Such emphases give the curriculum a special focus that can be introduced in addition to the content and processes outlined in the courses. This approach is discussed in "Curriculum Emphases - Blending Curricular Aims With Content", in section 11 of part 1 of this science guideline.

Typical emphases that might be developed in these courses include the following: the nature of science, science as a human endeavour in a cultural setting, the science/society relationship, an environmental ethic, and/or skill development. While every unit has some reference to each of the above and to other emphases, a particular emphasis, which may be stressed throughout an entire course or for one or more units at a time, should be highlighted so that it becomes a focal or integrating theme.

Student Activities

In each unit of study there is a section entitled "Student Activities". This section indicates mandatory laboratory work required of students. Teachers may substitute equivalent activities where appropriate. Those activities that are to be actually performed by students themselves are marked with asterisks. If time

and circumstances permit, the teacher should encourage students to do some or all of the unmarked activities as well. However, such activities may be demonstrated by a student or the teacher or may be discussed in conjunction with a textbook, film, computer program, or other learning material used as a resource. In any event, the scientific concepts and principles related to such unmarked activities, and identified in the objectives of the unit of study, shall be considered to be part of the prescribed course.

Generally, the best approach to the teaching of science is to ensure that the content develops directly from related student activities. In each unit of study the skills and processes of scientific work should be presented as the central component, from which the subject matter, applications, and implications emerge.

Sensitive Issues

In the development of the curriculum reflected in this guideline there is a distinct emphasis on the science-technology-society connection. Scientific applications and societal implications are mandatory components in each unit of study. Also, part 1 of this guideline underlines the need to incorporate morals/values education in science courses. Undoubtedly, this will give rise to the discussion of some sensitive issues.

Such discussions are important. Generally, they should be focused and provide an open forum for the expression of different viewpoints. In this regard teachers of science are urged to be familiar with Part 1 section 10.2 entitled "Values in Science Education", and pay particular attention to the principles to be

observed when dealing with sensitive issues in the science curriculum.

Evaluation of Student Achievement

Attention is drawn to the opening policy statements made in section 14 on "Evaluation" in part 1 of this guideline. The evaluation of student achievement in all Intermediate and Senior Division science courses must include certain components as follows:

- laboratory activities and reports ..... at least 15 per cent

In each unit of study in these courses section 5, entitled "Evaluation of Student Achievement", specifies some work that must be included in the students' term marks (exclusive of formal examinations) when their achievement is evaluated. In the majority of units, teachers are required to evaluate student activities and related laboratory reports. The proportion of the mark assigned may vary from one teacher to another in particular units. In order that the activity component of science be emphasized, the overall mark for an entire science course must include at least 15 per cent for the evaluation of student achievement in laboratory skills and reports.

Cross References

In the descriptions of each unit of study in the courses outlined in this document, cross references are provided in parenthesis. These references are included to illustrate some examples of the relationships among the various parts of the unit.

Particular Features of the Grade 12 Applied Physics Course

Units of Study and Their Time Allocations

The following chart provides an overview of the units of study in this course and indicates the time to be allocated to each unit.

Applied Physics, Grade 12, General level (SPA 4G)

Units	Time Allocations
Core	
1. Sound	16 h
2. Light and Colour	16 h
3. Heat	16 h
4. Electrical Energy	16 h
5. Motion	16 h
	80 h
Optional Choose 3 complete units	
1. Fluids	10 h
2. Nuclear Energy	10 h
3. Properties of Solids	10 h
4. Time	10 h } 30 h
5. Distance: Measurement and Applications	10 h
6. Locally Designed Unit	10 h
	110 h

This course is the first course in physics offered at the general level. It has two primary aims. First, it is designed to provide students with an understanding of some important principles of physics and also an appreciation of technology as an application of these principles. Second, students will study concepts such as energy and develop skills in measurement and graphing needed to continue into technological science courses. This and the additional course in technological science will provide important background information for technical and technological programs at the Colleges of Applied Arts and Technology.

Fundamental physical and mathematical concepts have been limited to those that are essential and applicable to the units that have been selected for study. More advanced concepts in physics are included in the Grade 12 technological science course.

The interrelationship between science and society is important in an applied science course. The applications and societal implications sections of each unit are therefore important features of this course.

It is intended that the overall evaluation of student achievement will reflect the primary emphasis on practical laboratory work and include other components as indicated in Part 1. In this course 50 per cent of the evaluation for a unit is specified. The balance of the evaluation for the unit is to be established by the teacher.

The optional unit, entitled "Locally Designed Unit", may be used to introduce a new area of physics not described in the guideline or to include new work that expands on previous topics in the course. If new topics are introduced in a locally designed unit, care should be taken to avoid physics topics that are included in units of the Technological Science, Grade 12, General Level, unless this course is not likely to be taken by the students.

Applied Physics

Core Units:

1. Sound
2. Light and Colour
3. Heat
4. Electrical Energy
5. Motion

Optional Units:

1. Fluids
2. Nuclear Energy
3. Properties of Solids
4. Time
5. Distance: Measurement and Applications
6. Locally Designed Unit

Applied Physics, Grade 12, General Level (SPA 4G)

Core Unit 1: Sound Time: 16 h

One of our senses involves the ability to receive and process sound. The ear is an instrument that provides us with useful and impressionistic information. Sound is very important in our ability to communicate and learn as well as enjoy all aspects of our lives.

Music plays a significant role in the lives of many people, and a study of musical instruments makes a unit on sound relevant. The physiological effects of loud music and noise and general characteristics of sound are examined as they affect our everyday lives.

This unit may be divided into topics such as the following:

- Production of sound
- Waves and the transmission of sound
- The ear and hearing
- Characteristics of sound
- Speed of sound
- Musical instruments

Objectives

Attitudes. Students will be encouraged to develop:

a) a curiosity about how we hear sound (4b);

b) a curiosity about how sounds are produced;

c) a concern for the damage that can be caused by any loud sound such as loud music (4b, 4c, 4d);

d) an appreciation for how certain structures are designed to enhance or suppress sound (3d, 3f, 3i, 4d).

Skills: Students will have the opportunity to develop skill in:

a) inferring causes for changes in characteristics of the wave pattern on an oscilloscope which is monitoring sound (2c);

b) drawing diagrams to illustrate effects on an oscilloscope wave pattern caused by characteristics of sound (2c);

c) interpreting observations to draw diagrams which illustrate wave types, interference patterns and standing wave patterns (2a, 2g, 2h);

d) measuring the time required for sound to travel a certain distance (2d);

e) recording and organizing observations in a table or chart (2d, 2e);

f) calculating the speed of sound (2d);

g) controlling variables when investigating the factors affecting the frequency of a vibrating string (2e);

h) interpreting observations to develop conclusions about:

  i) how the lack of a medium affects the transmission of sound (2a);

  ii) the relationship between the tension, length or diameter of a string and the frequency of a stringed instrument.

  iii) how the properties of a surface affect the reflection of sound (2f);

i) manipulating equipment in the determination of resonance lengths of closed and open air columns (2h).

Knowledge. Students will be expected to:

a) describe the cause of any sound (2a);

b) describe transverse and longitudinal wave diagrams (2a);

c) give evidence that sound is a pressure wave and a transmission of energy (2a);

d) give evidence that a medium is required for the transmission of sound (2a);

e) state the frequency range to which a human ear normally responds;

f) describe factors which can contribute to hearing loss and identify how to reduce their effects (2b, 2c);

g) identify and describe the functions of parts of the ear (2b);

h) identify the wave characteristics which determine the pitch, loudness and quality of a sound (2c);

i) describe an example of sound interference (2g);

j) state the law of reflection that is demonstrated when sound reflects from a hard, flat surface (2f);

k) describe techniques which can be used in the home and in industry to reduce reflections of sound;

l) explain what is meant by resonance in sound and give an example (2h);

m) describe how different notes are played on both a wind and a string instrument and explain why this procedure works (2e, 2h).

Student Activities

Students are to:

*a) use a slinky to produce transverse and longitudinal waves and compare the production and characteristics of each including the transfer of energy (8a, 8d);

*See the subsection entitled "Student Activities" on page 7.

*b) identify and explain the function of the parts of the ear with the aid of a diagram;

*c) determine, using an oscilloscope, the effect on the wave of variations in pitch, loudness and quality of sound (6a, 6b);

*d) determine the speed of sound in air (8c);

*e) investigate the effect of factors such as length, diameter and tension on the frequency of a vibrating string;

f) investigate reflection and absorption of sound using different surfaces and materials (8d);

*g) investigate interference of sound;

h) investigate resonance of sound in open and closed air columns (8b, 8e).

3. Applications

a) The flight of supersonic aircraft has to be restricted to specified flight corridors to prevent damage to buildings by the pressure wave called a sonic boom.

b) Untrasonic waves are used in diagnostic medicine, non-destructive testing of materials, cleaning, sterilizing, burglar alarms, and insect control.

c) Sound of high frequency and intensity can cause structural damage of materials.

d) Sound suppression, abatement, enhancement, and reflection are considerations in the design of structures, buildings, and theatres.

e) A depth-determining device called SONAR is used on military and commercial ships, fishing boats, and pleasure craft.

*See the subsection entitled "Student Activities" on page 7.

f) Knowledge of sound interference is applied in the design and location of stereo speakers. Specially designed rooms are often used for stereo demonstrations.

g) The reflection of sound by a parabolic dish is applied in the kind of microphone that is used to pick up bird songs. The same kind of microphone is used by TV crews at sporting events to pick up the chatter on the players' bench and on the playing field.

h) Knowledge of resonance is applied in the design of musical instruments and in the orchestration of instruments.

i) Sound levels are reduced in the home by using sound absorbing materials in construction and for furnishings.

Societal Implications

a) Music, in a variety of forms, is a part of daily life for most people.

b) Some people risk ear damage from loud music yet they will not tolerate sound of lower intensity in their work place.

c) Because people are very conscious of noise pollution, the locations of traffic arteries and supersonic aircraft flight corridors are issues that should be dealt with by a variety of interest groups and the government.

d) A great deal of money is spent by individuals and corporations to minimize noise levels at homes, on the job, and in our environment.

e) The musical entertainment industry offers career opportunities on the performance, production, promotion, and technical levels.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) explanations for observations in laboratory activities;

b) diagrams of wave types, the ear, variations in sound characteristics, interference and resonance.

6. Safety Considerations

a) Electronic devices and power supplies should have appropriate safety approval.

b) If electrical circuits are to be connected by students the power supply should not be turned on until the teacher has checked the circuitry for continuity and polarity.

c) care must be taken with respect to the magnitude of sounds produced and the proximity of the ear to these sounds.

d) See also the unit on electrical energy (CU 4).

7. Possible Extensions

Some students might:

a) use a sound-level meter to determine the sound intensity at various locations and distances relative to a source. The results can be displayed using graphs or charts;

b) tune an instrument such as a guitar or a clarinet by using beat frequency;

c) discuss how reflected sound waves (SONAR) can be used to calculate water depth;

d) give oral, written, audio, or audio visual reports on topics such as the following:

   i) the design and operation of speakers in audio systems;

   ii) the design of an electronic synthesizer;

   iii) the human voice.

Some Teaching Suggestions

a) Students should understand that sound is a pressure wave that is the result of a vibration and that the pressure wave transmits the energy of the vibration. The energy is transmitted by the wave, not the air. One way this can be shown is by forming a soap bubble on the bell of a trumpet and showing that as the trumpet is played the bubble stays intact.

b) A dust pattern in Kundt's tube can be produced with the resonating rod, by blowing air with a high speed blower across the mouth of the tube or by an audio generator and a small loud speaker which makes the air column resonate. The dust mounds can be related to compressions (high pressure regions) in the sound wave.

c) Sound can be transmitted through air, water, and a solid such as a desk top or a metal bar to show that different mediums will conduct sound. If a vacuum pump and bell jar are available students can be shown that sound cannot be transmitted without a medium.

d) There can be discussions about acoustics in buildings and theatres, sound abatement near high density traffic, sound receivers using parabolic reflectors, location of stereo speakers in cars and in the home, and beats.

e) Musical instruments such as a guitar or trombone can be used to show resonance.

Applied Physics, Grade 12, General Level (SPA 4G)

Core Unit 2: Light and Colour Time: 16 h

A great variety of sensory input enters the eyes, and sight is certainly a very highly valued sense. Devices such as microscopes, telescopes and cameras have been developed that extend vision and make permanent records of things we see. Our environment is enhanced by colour, a characteristic that has become important in many aspects of our lives. In this unit students will investigate reflection and transmission of light and colour. These phenomena regularly affect us and have many familiar applications.

This unit may be divided into topics such as the following:

- Colour
- Reflection
- Plane and curved mirrors
- Convex and concave lenses
- The eye
- Total internal reflection

Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation for the importance of the sense of sight in their lives and the need for proper care of the eyes;
b) an appreciation of the psychological effects of colour (3h, 4c);
c) an appreciation for the relationship between basic physical principles and applications of these principles (3a, 3c, 3d, 3e, 3f, 3i).

Skills. Students will have the opportunity to develop skill in:

a) controlling variables such as intensity and distance in an experiment in which different filters are used with a given light source to observe the colour of transmitted light (2b);

b) observing images in plane and spherical mirrors, and convex and concave lenses (2c, 2e, 2f, 2i);

c) locating images produced by plane and concave mirrors and convex lenses (2c, 2e, 2i);

d) making generalizations about the location and characteristics of images produced by plane and spherical mirrors (2c, 2e, 2f);

e) drawing ray diagrams to illustrate:

   i) how the eye sees an image in a plane mirror (2d);

   ii) an incident ray of light travelling from an object to a plane mirror and to convex and concave mirrors and the resultant reflected rays of light (2d, 2h);

f) observing the effects that different transparent materials have on light passing through them and then drawing diagrams to show the path of light (2g, 2h);

g) constructing ray diagrams to scale to locate images produced by concave mirrors and convex lenses given the focal length and location of the object (2e, 2i);

h) following procedures in setting up equipment to observe the behaviour of light (2c-2j, 2l);

i) interpreting observations of the refraction of light through different materials to develop general rules governing refraction (2g, 2l);

j) recording observations of the behaviour of light under differing circumstances (2d, 2e, 2g-2i, 2l).

Knowledge. Students will be expected to:

a) identify (1) the additive primary colours (ii) the secondary colours and (iii) the colours resulting from various combinations (2a);

b) explain why objects appear a certain colour when illuminated by light of different colours (2a);

c) explain the operation of a coloured filter (2b);

d) list the characteristics of the image produced by a plane mirror;

e) place labels on a diagram showing reflection from a plane mirror indicating the: incident ray, reflected ray, normal, angle of incidence, angle of reflection (2d);

f) state the laws of reflection (2d);

g) distinguish between regular and diffuse reflection and give an example of each;

h) locate the following on a diagram of a spherical mirror: vertex, centre of curvature, principal axis focal point (2e);

i) describe the location and list the characteristics of the image formed by a spherical mirror, given the location of the object (2e);

j) describe the changes in direction that light will experience as it enters a transparent material of different optical density at an oblique angle (2g);

k) describe the effect that i) a convex ii) a concave transparent shape has on parallel incident rays of light (2h);

l) describe changes in the image produced by a convex lens when the object is moved to increasing distances beyond the principal focus (2i);

m) describe the function of each of the major parts of the eye and locate each on a diagram of the eye (2k);

n) describe what is meant by i) nearsightedness ii) farsightedness and iii) astigmatism; identify possible causes of each and indicate the lenses needed to correct each (2h);

o) describe a procedure that will demonstrate that white light is composed of the spectral colours (2m);

p) list in order the colours of the visible spectrum (2m);

q) describe the conditions needed to produce total internal reflection (2l);

r) identify applications for i) total internal reflection ii) optical fibres (2l).

2. Student Activities

Students are to:

*a) record the appearance of coloured objects when placed separately under red, blue, yellow and green light;

*b) record the colour produced when white light is shone through individual filters and combinations of different filters;

*c) locate the image produced in a plane mirror and determine its characteristics;

*d) compare the angle of incidence and the angle of reflection when light is reflected from a plane mirror;

*e) locate the image produced by a concave mirror when an object is at various positions in front of the mirror, and in each case, determine the characteristics of the image (6a);

*f) determine the characteristics of the image produced by a convex mirror when an object is placed in front of the mirror;

*See the subsection entitled "Student Activities" on page 7.

g) observe, and construct diagrams to show, the refraction of light as it enters and exits different transparent materials of various shapes; identify the direction of bending in each case and derive a conclusion (8a);

*h) investigate the effect that convex and concave mirrors and transparent shapes have on parallel rays of light;

*i) observe and describe the image formed by a convex lens for various locations of the object and construct ray diagrams to illustrate image formation when the object is beyond the principal focus (8a);

j) determine the characteristics of the image produced by a concave lens;

*k) identify on a diagram of the eye the major parts and describe the function of each (8b);

l) investigate the effect of increasing the angle of incidence as light passes from a transparent material into air and observe total internal reflection and determine the conditions needed to produce total internal reflection;

m) determine that white light is composed of the spectral colours.

Applications

a) Lens systems are used in many common optical instruments including cameras, projectors, microscopes and telescopes.

b) Atmospheric refraction leads to extended visibility of the sun above the horizon, apparent water in the distance on a highway, and other mirages.

c) The camera performs some of the same functions as the eye.

*See the subsection entitled "Student Activities" on page 7.

d) Optical fibres are used in an ever increasing number of applications such as medical diagnosis and information transmission.

e) Total internal reflection is employed in prism-type binoculars, periscopes and single lens reflex cameras.

f) Curved mirrors are used as cosmetic mirrors, as rear-view mirrors on vehicles, and as surveillance mirrors in stores.

g) The colour of sets and costumes in theatrical and stage productions can be controlled by illumination with combinations of coloured lights.

h) Colour coordination and impact influence the design of fashions and cosmetics for both men and women.

i) A colour television picture tube operates on the principles of the additive theory of colour.

4. Societal Implications

a) The development of optical instruments has permitted the study of microbiology which has brought many benefits in health care.

b) The telescope provided data about the moon which gave significant information to the space program.

c) Technological applications of principles of light and colour have provided many devices such as lasers that have improved scientific research techniques as well as the quality and enjoyment of life.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) laboratory work and reports of activities;

b) diagrams, including ray diagrams, illustrating the behaviour of light.

Safety Considerations

a) Appropriate procedures should be developed and followed if candles are used as light sources. Ray boxes or similar devices can be used to determine the path of light through transparent objects. Lamps or other sources can be used with lenses to form images. All electrical equipment used should have appropriate safety approval.

b) If lasers are used in this unit, students must be instructed not to look directly down the beam.

Possible Extensions

Some students might:

a) investigate the lens system used in optical instruments such as telescopes and binoculars and explain how each works;

b) study colour vision and colour blindness. Students can check to see if they are colour blind. An optometrist or eye doctor might speak on these topics;

c) investigate the importance and psychology of colour in advertising and marketing;

d) observe the production of prints from colour photographic film;

e) explore the variety of careers in diverse fields involved with all aspects of light and colour.

8. Some Teaching Suggestions

a) This unit involves considerable work with diagrams. Students should draw diagrams with rulers and label them appropriately.

b) Photography can provide a link between topics in this unit. A comparison of the structure and operation of the camera and the eye can be made. Reflex cameras use reflecting prisms. The purpose of various photographic filters can be discussed as well as the makeup of colour film and how it reacts to light to produce a picture.

c) Speakers may be available in the community that can discuss or even demonstrate (i) optical fibres, (ii) telescopes, (iii) colour vision, (iv) colour television and (v) colour in advertising.

d) Computer software is available on colour and light, and computer drawn diagrams and simulations might be considered.

Applied Physics, Grade 12, General Level (SPA 4G)

Core Unit 3: Heat Time: 16 h

The study of heat energy led early scientists to discover important principles in physics. The application of these principles in both theoretical and applied physics has increased knowledge and served as an impetus to technology. Heat energy has a wide range of applications and is the major form of energy used in our technological society, either directly or indirectly. It is the form of energy that powers our transportation systems. It is involved in the processing and manufacturing of many materials used in industry and in consumer goods. Heat transfer from a variety of sources, and an understanding of home heating systems and related concepts, are emphasized in this unit.

This unit may be divided into topics such as the following:

- Heat and its transfer: applications in the home
- Home insulation
- Heating and cooling curves
- Heat exchange in mixtures
- Temperature vs heat
- Refrigerators or heat pumps
- Heat engines
- Variety of heat related topics

Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation for the importance of heat energy in technology and in nature (3a, 3d, 4a, 4c-4f);

b) an awareness of the possible effects resulting from advancements in technology (4a, 4f);

c) a commitment to conservation practices (3b, 3d, 4d).

Skills: Students will have the opportunity to develop skill in:

a) measuring temperature, mass, and volume of different materials (2b, 2d-2g);

b) recording and organizing data from experiments and activities (2d-2g);

c) using the equation $Q = mc\,t$ to solve problems involving heat transfer (2e-2g);

d) plotting and interpreting heating and cooling curves (2d);

e) carrying out procedures according to instructions (2a, 2d-2g);

f) researching information and preparing reports (2c, 2h).

Knowledge. Students will be expected to:

a) explain the transfer of heat by conduction, convection, and radiation in home heating systems and/or in other applications (2a);

b) describe the effect that the colour and texture of an object has on radiation and absorption of heat (2b);

c) explain what is meant by the R-value of a material (2c);

d) state the principle of heat exchange in mixtures (2e);

e) use the equation $Q = mc\,t$ and state the factors that determine the amount of heat energy gained or lost by a substance (2d, 2e-2g);

f) select materials best suited for heat storage from tables of specific heat capacity (2f);

g) identify the changes of state which can be experienced by a

substance and state whether heat is gained or lost during the change (2g);

h) state the major points of the kinetic molecular theory of heat (8b);

i) explain heat transfer by conduction and convection and changes of state, using the kinetic molecular theory (2a, 2g);

j) explain the differences between temperature and quantity of heat (2d, 2f, 2g);

k) describe the operation of a refrigerator, air conditioner or heat pump (8h);

l) describe the operation of a heat engine.

Student Activities

Students are to:

a) investigate heat transfer by conduction, convection and radiation (8a);

b) experimentally determine the effect of colour on radiation and absorption of heat (8f);

c) investigate samples and related literature dealing with popular commercial insulation and building products and compare the R-values and costs (8e, 8i);

*d) perform experiments to investigate the rate at which different liquids warm up and/or cool down, and plot heating or cooling curves from the data obtained (6b-6f, 8d);

*e) experimentally determine the amount of heat energy exchanged when hot and cold water are mixed (8c);

f) experimentally determine the specific heat capacity of a metal (6b, 6g, 8d);

*g) determine the latent heat of fusion of ice (8g);

*See the subsection entitled "Student Activities" on page 7.

*h) prepare an essay, report, or video, on a heat-related topic such as:

i) photochemical smog;

ii) solar energy;

iii) futuristic homes;

iv) the greenhouse effect;

v) possible alternatives to the conventional heat engine;

vi) thermal pollution (8j).

3. Applications

a) Heat energy is one of the major energy sources in our society. Heat may also be used to produce the other major energy source - electricity.

b) Thermopane windows, storm doors, and insulating materials in general are designed using the principles of heat transfer.

c) The terminology related to heat engines and their principles of operation is used in automobile advertising. Examples are - 2 L engine, fuel injection, turbo charging.

d) The search for alternate energy sources and the need for energy conservation are based on an understanding of heat.

e) Space craft, such as the Shuttle, use ceramic shielding heat ablation for heat dissipation.

4. Societal Implications

a) Heat pollution of rivers and lakes is cause for concern in some parts of the globe.

b) The use of heat energy in a variety of ways has improved our standard of living.

*See the subsection entitled "Student Activities" on page 7.

c) Innovative heating and cooling systems may be necessary in future homes and buildings.

d) Conservation of energy and development of alternate energy sources will become more important as supplies of conventional fossil fuels dwindle.

e) Advances in technology have occurred when inventions improve the efficiency of energy conversions (Watt's steam engine) or when new forms of energy are harnessed (electricity).

f) Pollutants from some heat engines may pose serious health hazards and create environmental problems.

Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) laboratory reports and practical work (a minimum of 20 per cent);

b) essays or reports on heat-related topics;

c) problem assignments.

Safety Considerations

a) Open flames should be used only in a laboratory with flat desks or tables, adequate ventilation, a fire extinguisher, and fire blanket.

b) Students should wear protective eye wear when using flames or heating liquids. Loose hair and clothing should be tied back.

c) Liquids other than water should be heated in a water bath or on a hot plate rather than over an open flame. Some liquids or their vapours can ignite easily.

d) When liquids other than water are heated, there should be adequate ventilation to remove the vapours.

e) When alcohol or other flammable gases are present in the laboratory, there should be no open flames.

f) Volatile liquids like alcohol should be stored in approved containers. The containers should not be removed from the storage area.

g) Special precautions should be taken to avoid burns when handling hot containers and liquids.

7. Possible Extensions

Some students might:

a) evaluate the merits of different house plans and materials for their effectiveness in minimizing heat gain/loss;

b) study proposed designs of heat engines;

c) study properties of ceramics used as heat shields or study ablative cooling techniques;

d) investigate the use of remote sensing for pollution monitoring, crop management, cancer detection, and resource exploration;

e) develop a model for the earth-sun system as a heat engine;

f) study possible causes for the ice ages;

g) investigate the processes of extracting and refining petroleum.

8. Some Teaching Suggestions

a) If the quantity of equipment is limited, students may rotate through different laboratory stations to investigate heat transfer experiments.

b) A model of the kinetic molecular theory of heat can be developed

using one or more of:

i) demonstration models;

ii) Brownian motion demonstrations;

iii) audiovisual techniques.

c) Heat flow from higher to lower temperatures can be illustrated by having students place both hands in separate baths of water; one bath being very cold, the other bath being warm. After several minutes have the student place both hands simultaneously into a lukewarm bath of water.

d) i) The relationship between heat gained and mass can be determined from heat curves obtained when different masses of a liquid such as water are heated. The temperature of each liquid should be used at one minute intervals. The data for each liquid can be used to plot a heating curve on a "temperature versus time" graph.

ii) The fact that different substances have different heat capacities can be determined from heat curves obtained when identical masses of different liquids are allowed to cool. The liquids should be warmed by immersion in a hot water bath. The temperature of each liquid should be taken at one minute intervals. The data should be used to draw a separate heat curve for each liquid on the same graph.

e) Other heat curves can be obtained by placing hot water in a calorimeter and measuring the rate of cooling. The cup in the calorimeter can be surrounded (packed) by paper, styrofoam, etc. From the heating curve of the water in each case, the insulating property of the packing material can be inferred.

f) Identical quantities of water can be placed in containers of different colour (example, silver versus black). The rate at which the water warms up when the containers are exposed to a heat source such as an incadescent lamp under identical conditions can be used to plot heat curves. Conversely, identical amounts of water in different coloured containers can be allowed to cool and cooling curves obtained.

g) To determine the heat of fusion of ice, cubes of ice can be placed into a known mass of warm water inside a calorimeter or styrofoam cup. The temperature of the water should be measured before the ice is added. The mixture should be stirred until the temperature reaches 0°C, with the temperature recorded at one minute intervals. The excess ice should be removed and the mass measured. The final mass of water in the container should be measured and the mass of ice melted should be calculated. By equating the heat lost by the warm water to heat gained by the ice, the heat of fusion of ice can be determined.

h) Students should be provided opportunities, if possible, to inspect dismantled small engines, models of heat engines, or air conditioners.

i) Students can be asked to contact and then visit local businesses to obtain literature on insulating characteristics of materials.

j) The preparation and presentation of reports on heat-related topics may be done in small groups to encourage co-operation and to utilize individual student strengths.

Applied Physics, Grade 12, General Level (SPA 4G)

Core Unit 4: Electrical Energy Time: 16 h

Every day electrical energy is used to power devices that are a part of our current lifestyle. Life would be considerably different without electric lights, washers, dryers, refrigerators, computers and telephones. Many industrial processes exist because electric motors have been developed to perform specific tasks through the use of electrical energy. In this unit students will study some of the electrical devices in our society and examine how electrical energy is readily available for use.

This unit may be divided into topics such as the following:

- Current, voltage and resistance
- Electric circuits - series and parallel
- Energy, power and costs
- DC motors
- Electrical generators
- Transformers
- Transmission of electrical energy

Objectives

Attitudes. Students will be encouraged to develop:

a) curiosity about how electrical devices work (3a-3d, 4a, 4d, 4g);
b) an appreciation of the large amount of electrical energy that is required to satisfy society's demands (3c, 4c-4f);
c) a concern for the wise use of electrical energy in order to conserve energy and financial resources (4e, 4g);

d) an appreciation for how scientists develop explanations for observed phenomena;

e) a respect for the potential hazards involved in working with electricity;

f) an interest in the variety of employment opportunities related to electrical energy. (3a-3d, 4c, 4d).

Skills. Students will have the opportunity to develop skill in:

a) following instructions to construct electrical circuits and building simple electrical devices (2a, 2b, 2e);

b) selecting appropriate range settings on ammeters and voltmeters (2a, 2b);

c) connecting and reading ammeters and voltmeters (2a, 2b);

d) recording ammeter and voltmeter readings in a chart or table (2a, 2b);

e) calculating the equivalent resistance when two loads are connected in series or in parallel (2b);

f) using the equations $V = IR$, $E = Pt$, $P = VI$ and COST = E (cost per energy unit) to make simple calculations about an electrical circuit (2a, 2d, 2h);

g) reading an electric meter that records electrical energy use (2c);

h) inferring the causes of such things as the blowing of a fuse by a toaster and kettle plugged into the same circuit or electromagnetic induction (2d);

i) drawing diagrams of simple series and parallel circuits (2b).

Knowledge. Students will be expected to:

a) identify the quantities and the units for each term in the Ohm's Law formula (2a);

b) explain why outlets are wired in parallel and not in series (2b);

c) state the function of a fuse or circuit breaker and explain how it works (2d);

d) explain, with the aid of a diagram, why the armature of a DC electric motor rotates (2e);

e) list the factors that affect the rate of rotation of an electric motor (2e);

f) describe the induced current produced in the armature coils of an electrical generator during one complete rotation (2f, 2g);

g) explain the difference between direct and alternating current (2f);

h) list the factors that affect the strength of the induced current in an electrical generator (2g);

i) describe the differences in construction and function between step-up and step-down transformers (2h);

j) state the relationship between output and input currents, voltages and power in a transformer when the number of turns in the primary and secondary coils are known (2h);

k) identify the type of transformer used before electrical energy is transmitted and the type used before it enters a home and explain the reasons for the choices (2h);

l) name the electrical quantity measured in: amperes, volts, ohms, watts and joules (2a - 2d, 2h).

2. Student Activities

Students are to:

*a) construct a simple circuit and use it to verify Ohm's law (6);

*b) construct a simple series circuit and a simple parallel circuit and determine the equivalent resistance of each combination (6, 8a);

*c) read an electric meter daily for several days to determine the electrical energy used and calculate the cost using local electrical rates;

*d) record the information found on the electrical plates of several electrical appliances in the home or school and determine the cost for normal operating periods;

*e) build a working DC electric motor using simple materials or a kit (6c, 6d, 8c);

f) experimentally determine how a current can be induced in a coiled conductor (6b);

g) investigate the factors which affect the strength of an induced current (6b, 8b, 8c);

h) observe the voltages in the secondary and primary coils of a step-up and step-down transformer (6a, 6b, 6d).

3. Applications

a) Loud speakers, electromagnetic relays or solenoids in cars, washing machines, dishwashers, door bells, and magnetically propelled monorail trains use changing magnetic fields for lifting and propelling.

b) Simple electrical motors in such items as sewing machines, food processors, hair dryers, car windows, garage door openers, fans,

*See the subsection entitled "Student Activities" on page 7.

refrigerators, clothes dryers, and electric razors are applications of electromagnetism.

c) Relative motion between conductors and magnetic fields are used to generate electricity in applications on as large a scale as the production of electrical energy by Ontario Hydro and on as small a scale as bicycle light generators. Changing magnetic fields are used in transformers which distribute electricity across Ontario, operate electric door bells, and charge the rechargeable batteries in items such as hand-held calculators.

d) The same electric and magnetic fields that make motors and generators work also are directly involved in solid state micro circuits used in communication systems and computers.

Societal Implications

a) The quality of life for many is enhanced by the variety of devices that have been developed to convert electrical energy into useful work, light, and sound.

b) The development of electrical lighting has permitted work to be carried out around the clock.

c) A large part of the Canadian economy is dependent on the electrical industry. The manufacture and distribution of electrical goods is a major source of employment and contributes to the national wealth.

d) The ease with which electrical energy can be converted to other forms of energy has led to an increase in the number and types of electrical devices in our society. The design, development, manufacture, and distribution of these goods now and in the future will provide many career opportunities in such fields as electrical engineering, electrical technology, merchandising and industrial design.

e) A number of issues involved with the conservation, production, and distribution of electrical energy are subject to public debate.

f) Wide distribution of electrical energy has brought modern conveniences to most of the population of Ontario.

g) Since certain appliances use a large amount of electrical energy, the energy costs should be considered before purchase or excessive use.

h) The demand for more and more cheap electrical energy has resulted in an increase in the use of nuclear power.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) laboratory work projects and reports;

b) ability to properly connect meters in circuits and read them correctly;

c) construction and/or assembly of electrical circuits and devices;

d) problem assignments using various formulas.

6. Safety Considerations

a) Power supplies, meters, and circuit components should have appropriate safety approval.

b) Students should be cautioned that the range of any meter used must be appropriate for the current or voltage being measured.

c) Power should not be turned on in any circuit until the teacher has checked the circuitry for continuity, polarity, and correct meter ranges.

d) Students should be well informed of the hazards associated with electric circuits and be told not to touch circuit connections

once the power supply has been turned on.

e) Students should be warned that dry cells may explode if shorted out.

Possible Extensions

Some students might:

a) discuss magnetic levitation as a means of propulsion in transportation systems.

b) investigate and demonstrate how the motor principle is used to measure current and voltage in ammeters and voltmeters.

c) construct a current balance to show the factors that affect the force between current-carrying conductors.

d) study the construction, action and applications of relays.

Some Teaching Suggestions

a) Activity (b) could be designed so that students can see that for a fixed applied voltage, the energy dissipated by circuit components depends on circuit configuration and the resistance of the various components. The values of the energy dissipated and the resistance can be determined using appropriate equations or graphical techniques.

b) Activities on electromagnetic induction should be designed so that students can manipulate the variables such as number of coils, the strength of the current and the type of core in the coils. They should make generalizations about the effects of the variables rather than establish mathematical relationships.

c) The devices that are used to illustrate the motor principle and electromagnetic induction can be designed and constructed by the students.

Applied Physics, Grade 12, General Level (SPA 4G)

Core Unit 5: Motion Time: 16 h

Motion is so natural to us that we are often not aware of it, and fail to realize its significance. The analysis of motion often helps us make inferences about the energy possessed by an object and the forces acting on it. In order to provide students with an understanding of some of the concepts associated with motion, this unit will involve students in the examination of several kinds of motion, some of the factors that govern motion, and a number of conclusions about motion.

This unit may be divided into topics such as the following:

- Speed
- Distance-time and speed-time graphs
- Acceleration (Scalar)
- Force and motion
- Work and energy
- Kinetic and potential energy
- Energy transformations

. Objectives

Attitudes. Students will be encouraged to develop:

a) curiosity in seeking explanations for phenomena involving motion (3a-3c, 4a);

b) an appreciation for the need to use good judgment when operating a vehicle or riding a bicycle or motorcycle (3a, 4a, 4c).

Skills. Students will have the opportunity to develop skill in:

a) measuring distances and times (2a, 2b, 2e, 2f);

b) calculating speed, average speed, acceleration* and kinetic energy (2a, 2b, 2f);

c) recording experimental data (2);

d) plotting distance-time and speed-time graphs and determining their slopes (2a, 2b);

e) making and testing hypotheses and designing experimental procedures (2d);

*Acceleration problems required in this unit should only deal with situations in which students are given the change in speed and the elapsed time i.e. $a = \frac{\Delta v}{\Delta t}$. Problems are to be limited to uniform acceleration.

Knowledge. Students will be expected to:

a) define: i) average speed, ii) uniform speed iii) uniform (scalar) acceleration iv) inertia (2a, 2b);

b) apply the formula $V_{av} = \frac{\Delta d}{\Delta t}$ to determine the average speed of a moving object (2a, 2b);

c) state the significance of the slope in a:

i) distance-time graph,

ii) speed-time graph (2a, 2b);

d) select the appropriate motion graph when asked to determine:

i) average speed,

ii) acceleration (2a, 2b);

e) apply the formula $a = \frac{\Delta v}{\Delta t}$ to determine the acceleration of a moving object (2b);

f) describe the speed of an object given its:
   i) distance-time graph,
   ii) speed-time graph (2a, 2b);

g) explain why a force applied to a stationary object may not cause it to move;

h) explain what happens when a single unbalanced force acts on an object;

i) state the relationship between the forces of static and kinetic friction and;
   i) the mass of an object,
   ii) the nature of the surfaces in contact (2c);

j) draw free body diagrams to illustrate the forces acting on an object when it is:
   i) at rest,
   ii) moving with uniform speed in a straight line,
   iii) accelerating or decelerating uniformly;

k) state factors which affect the rate of fall of an object in air and define terminal speed (2d);

l) recall the definition of work and the formula $W = Fd$ and identify the newton and joule as the SI units of force and energy (2e);

m) define:
   i) kinetic energy,
   ii) potential energy;

n) describe the energy changes experienced by a body under free fall;

o) describe the relationship between work done and energy transformed;

p) state the law of conservation of mechanical energy;

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) experiments and lab reports;

b) graphing and graphical analysis.

6. Safety Considerations

a) If air tables or tape timers are used in any experiment, this equipment and wiring must be in good condition and have an appropriate safety approval.

b) If bicycles are used in motion experiments, instructions regarding safety precautions must be given to the students and then followed precisely.

7. Possible Extensions

Some students might:

a) determine the coefficient of friction for different types of surfaces;

b) discuss the friction effects involved with very high speeds in aircraft;

c) consider the relationship between the fuel requirements and the speed of a car. The reasons for imposing a lower speed limit in Ontario could be discussed;

d) students can determine their power when performing some mechanical task.

Some Teaching Suggestions

a) Students can attempt to walk a series of consecutive measured distances at a uniform rate to gather experimental data on motion. Acceleration and deceleration data can be obtained by having students ride a bicycle over a specially laid-out track which is free from all other traffic.

b) Curtain rod tracks bent into a U-shape can assist in demonstrating energy transfer and conservation.

c) Relate stopping distance to energy. Distance versus speed and distance versus speed squared can be plotted using data obtained from resources such as driver training manuals.

Optional Unit 1: Fluids

Time: 10 h

One of the technologies that has had an impact on modern society is that of fluids. There are few vehicles or pieces of machinery designed to carry large loads that do not have a hydraulic or pneumatic system for either power or control. Aerodynamics, which is the science of the fluid air, has given us the knowledge to fly and sail. Hydrodynamics, which is the science of water in motion, has given us the knowledge to move effectively through and over the water. In this unit students will study fluids at rest and fluids in motion to gain an insight into the applications of fluid technology.

This unit may be divided into topics such as the following:

- Air pressure
- Pressure in liquids including Pascal's law
- Buoyancy and Archimedes' principle
- Surface tension
- Fluids in motion
- Bernoulli's principle

Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation for the effects of fluids on our existence (3c, 3d, 3k, 4a, 4f);

b) curiosity about how fluids are used to do work (3b, 3c, 3g, 3h, 3j, 4b);

c) an appreciation of the reason for streamlined shapes in animals, structures, and vehicles (3f, 4d).

Skills. Students will have the opportunity to develop skill in:

a) measuring mass, volume of a liquid, and the force of gravity on an object (2c);
b) following instructions to construct a manometer (2b);
c) inferring causes of phenomena such as the changes in the height of a column of fluid (2b);
d) making and testing hypotheses and controlling variables for an investigation about which liquids will exhibit the greatest surface tension (2d);
e) drawing conclusions by observing the effects of moving fluids on objects (2g);
f) solving simple problems involving Pascal's law.

Knowledge. Students will be expected to:

a) define pressure (2a, 2b);
b) give some examples of phenomena that are caused by differences in air pressure and explain each (2a, 2b);
c) explain how a barometer measures air pressure (2b);
d) state the relationship between pressure in a fluid and depth (2b);
e) state Archimedes' principle and use it to explain related phenomena (2c);
f) explain and apply Pascal's law (2b);
g) explain what is meant by the term surface tension and give some examples (2d);
h) identify causes and methods of reducing turbulence in moving fluids (2e);

i) describe the relationship between the speed of a fluid and the cross-section of the conduit (2f);

j) describe the force effects of a fluid flowing over an object and give some examples (2g);

k) state Bernoulli's principle and give some examples of its application (2h).

Student Activities

Students are to:

*a) investigate several activities that illustrate air pressure, for example: drawing liquid through a straw, supporting a volume of water in an inverted container by means of a piece of cardboard, trying to lift a flat piece of glass from a smooth table top, the use of syringes (8e);

*b) construct a water manometer and use it to determine relative pressure at different levels in different fluids (6b, 8a-8d);

*c) investigate Archimedes' principle for objects that
   i) sink in water,
   ii) float in water;

*d) investigate qualitatively the difference in the surface tension of several different liquids (8f);

e) do a simple investigation of streamlining on the turbulence created by an object in a moving fluid (6c, 8g, 8h);

f) determine how a change in the cross-sectional area of a moving fluid changes the speed of the fluid;

*g) investigate the effects of a moving fluid such as air on objects located in it (8g);

*See the subsection entitled "Student Activities" on page 7.

h) do an investigation that illustrates Bernoulli's effect when a fluid flows through a constriction in a pipe such as a Venturi tube (8h).

3. Applications

a) The variation of pressure with depth in a fluid is taken into account in the design of dams, design and safe use of under-water breathing equipment (SCUBA), design and use of aircraftbreathing and pressurization systems.

b) Lift pumps and siphons operate because of the creation of a difference in air pressure between the inlet and outlet sides of the pump or siphon.

c) Pascal's Law applies to hydraulic systems. Examples are vehicle brakes and shock absorbers, hoists in a garage, hydraulic actuators, and the vascular system of mammals.

d) Water is conducted through the xylem in plants by capillary action.

e) Ships and submarines utilize Archimedes' principle.

f) The streamlining of vehicles, aircraft, and boats reduces the amount of energy needed to propel them.

g) A high speed jet of water can be produced from a hose by reducing the area of the nozzle through which the water flows.

h) There is a pressure difference produced on opposite sides of aircraft wings and hydrofoils because of their shape when the fluid flows over one surface faster than it does over the other.

i) An automobile carburetor and a jet water pump have a Venturi section which creates a partial vacuum.

j) Hydraulics and pneumatics are used in control systems.

k) Atmospheric pressure variations are important in weather forecasting.

l) Vaccum cleaners create a difference in pressure to draw in air.

Societal Implications

a) The great adventures of the last two decades have been the explorations of space and the depths of the sea. These accomplishments have been possible because of the application of knowledge of pressure to breathing systems and human physiology in high and low pressure environments.

b) Hydraulics and pneumatics have expanded the use of machines into applications where mechanical linkages are awkward and complicated.

c) The development of aircraft has opened up intercity and intercontinental travel to the point where few parts of the world are isolated.

d) The production and distribution of recreational sailcraft and aircraft are big industries.

e) There are many careers in pneumatics, hydraulics, and air and water transport.

f) Improvements in human health have occurred because of parallels drawn between hydraulic systems and the vascular system (e.g., valve control of blood flow).

g) Reduction of surface tension of water by soaps and detergents permits inexpensive, easy cleaning, promoting a high standard of hygiene.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) laboratory work;

b) laboratory reports;

c) oral or written descriptions or labelled diagrams of the design and operation of devices that work because of a difference in pressure or the flow of a fluid.

6. Safety Considerations

a) If volatile fluids like alcohol are used they should be kept away from flames, and the storage containers should be kept in a storage room.

b) If manometers are made of glass the students should be instructed on the safe handling of glass.

c) If a wind tunnel or fans are used as sources of flowing air students should be cautioned about the danger of getting near the moving blades.

d) Students and teachers should not be exposed to open containers of mercury.

7. Possible Extensions

Some students might:

a) determine the density of different liquids so that pressure in a liquid can be related to density as well as depth;

b) construct and use a hydrometer to determine the relative densities of different liquids;

c) determine the buoyant forces acting on different objects in different liquids;

d) demonstrate, using simple models the relative locations of the centre of gravity and the centre of buoyancy in ships and boats. Include in the discussion the centre of effort on the sail of a sail boat;

e) relate fluid friction in pipes to the type of fluids and the diameter of the pipe;

f) report on aerodynamic drag on aircraft or hydrodynamic drag on watercraft and identify the variables that affect drag;

g) report on how a pitot tube is used in the determination of airspeed in an aircraft;

h) discuss cavitation and water hammer.

i) "weigh" a can using air presure and area of contact of the car tires.

Some Teaching Suggestions

a) A manometer can be made of glass tubing or clear plastic tubing, bent in the shape of a U, and partially filled with coloured water. A pressure sensor for the manometer can be made by securing a thin rubber membrane over the plastic top of a thistle tube. The pressure sensor is connected to one of the arms of the manometer by means of a flexible tube. When the "pressure sensor" is held in a fluid the liquid in the manometer will be displaced.

b) Different liquids such as water, alcohol, oil, and concentrated salt water can be used to show that the pressure depends on the density of the fluid as well as the depth in the fluid. A tall container like a hydrometer jar will minimize the volume of liquid that has to be used. If the densities of the different

liquids are determined the relationship P = gd can be developed.

c) Pascal's law can be demonstrated if a container large enough for the pressure sensor to be moved around is available. A swimming pool is an ideal place to demonstrate Pascal's law. Students relate pressure on the ears with depth in a swimming pool.

d) A tall juice can punched with holes at several levels is an apparatus that will illustrate the variation of pressure with depth.

e) In activities 2a and 2b the kilopascal should be introduced as a unit of pressure and 101 kPa as atmospheric pressure at sea level. This pressure can be related to 760 mm of mercury and 10 m of water. A discussion of the variation of air pressure with altitude and a person's requirement to have between 110 mm and 160 mm of oxygen pressure for survival can be an interesting extension of these two activities.

f) The actual values of surface tension are not important. Students should know that the surface tension of different liquids is different. They should know that adding detergent to water changes the surface tension of the water.

g) It should be stressed that a fluid can be a liquid or a gas using water and air as examples. Whether the object moves through the fluid or the fluid flows over the object, the same effects are observed.

h) If suitable equipment to investigate the flow of fluids past objects and through pipes is not available, films, videotapes, computer simulations and blackboard diagrams can be good alternatives.

Applied Physics, Grade 12, General Level (SPA 4G)

Optional Unit 2: Nuclear Energy Time: 10 h

Nuclear energy is used in the generation of a significant part of the electrical energy in Ontario and in Canada. Radioisotopes have become important in medical and industrial applications. Research in nuclear fusion may lead to a future energy source. Because of these developments students should understand the nature of nuclear reactions and radioactivity. As future citizens they will then be better able to understand the long-term issues associated with the use of nuclear energy and radioisotopes.

This unit may be divided into topics such as the following:

- Radioactivity
- Radioisotopes and their applications
- Nuclear reactions
- Nuclear reactors: CANDU
- Nuclear waste management

Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation for the benefits and risks associated with ionizing radiation and the need to guard against unnecessary exposure (3a-3c, 3g, 4a, 4d-4f);

b) an open-mindedness in evaluating the issues associated with the nuclear industry (3g, 4a, 4b, 4d, 4f);

c) an appreciation of the importance of employing suitable management techniques when dealing with nuclear wastes (3g, 4f).

Skills. Students will have the opportunity to develop skill in:

a) recording and organizing experimental data (2b, 2c, 2f, 2g);

b) classifying materials according to shielding ability and, radiation according to penetrating power (2b, 2g);

c) constructing a graph illustrating radioactive decay over time and from it obtain half-life information (2c);

d) evaluating information in order to make decisions and value judgements such as risk-benefit analyses (2b, 2c, 2f, 2g).

Knowledge. Students will be expected to:

a) describe three different methods of detecting radioactivity and be aware of the symbols indicating radiation hazards (2a, 2b);

b) describe how a radioactive substance differs from a non-radioactive one and indicate the ranges of natural "background" radiation (2c);

c) name three types of radiation that could be emitted by a radioactive substance, compare their penetrating ability, and indicate "safe" or "allowable" radiation exposure levels (2b);

d) define: i) isotope
ii) half-life (2c);

e) describe three applications of radioactive isotopes;

f) state the meaning of nuclear fission and fusion;

g) name three products of a nuclear fission reaction;

h) describe the conditions under which a chain reaction can occur;

i) describe how a nuclear fission reaction can be controlled;

j) explain why controlled nuclear fusion might provide a valuable energy source in the future;

k) name the major components common to all nuclear reactors and describe the function of each (2d);

l) explain the function of a nuclear reactor in the process of generating electricity (2e);

m) describe three characteristics to be considered when determining methods for disposal of nuclear wastes (2b, 2c, 2f, 2g).

Student Activities

Students are to:

*a) observe and describe tracks in a cloud chamber left by emissions from a radioactive source (6a, 8a);

b) compare the penetrating power of alpha, beta, and gamma radiation through a given material (6a, 8a);

*c) collect data from an activity simulating radioactive decay or from an isotope minigenerator, plot a graph, and determine the half-life (8c);

*d) label, on diagram of a CANDU reactor, the major parts and describe the function of each (8c);

*e) investigate the components used to generate electrical energy in a nuclear powered station and describe the function of each (8c);

*f) determine the effect of distance from the source on the radiation received and plot a graph of distance against radioactive counts per unit time (6a, 8a);

g) determine the shielding capabilities of various materials (6a, 8a, 8e).

Applications

a) Everyone working near radiation sources is required to wear an identification badge which contains radiation detectors in order

*See the subsection entitled "Student Activities" on page 7.

to monitor exposure.

b) Radioactive isotopes are used as tracers and for medical diagnosis and treatment.

c) Radiation is used to kill microorganisms, sterilize insects, and prevent spoilage of food.

d) Nuclear fission is used as an energy source in the generation of electricity.

e) Properties of some materials have been enhanced by exposure to radiation (e.g., plastics, safety glass).

f) Radioactive dating has been used to determine the age of relics, fossils, and the earth itself.

g) Nuclear waste disposal procedures must be designed to minimize the effects of radiation.

h) Nuclear fusion is the energy source of the sun and stars.

4. Societal Implications

a) Radiation can produce mutations in reproductive cells with results that can be either beneficial or harmful.

b) Nuclear energy is one energy alternative in a time of rapidly diminishing fossil fuels, but one which requires high initial investment of money.

c) The technology associated with nuclear energy has generated many new career opportunities in medicine and industry.

d) The nuclear industry has created situations in which the risks and benefits must be carefully examined and evaluated.

e) Life expectancy has been increased partly because of the developments and advances in nuclear medicine.

f) Nuclear waste management has created and will continue to create political debate.

g) Canada has made significant contributions in the fields of nuclear energy and nuclear technology.

Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit should be based on students':

a) graphs and diagrams;

b) interpretations of results of activities;

c) written answers or verbal reports obtained from reading assignments.

Safety Considerations

a) Radioactive samples should be handled and stored according to currently accepted practices.

Possible Extensions

Some students might:

a) investigate the characteristics, sources and effects of other forms of radiation such as X-rays, cosmic rays and ultra-violet radiation;

b) research radioactive dating techniques;

c) present reports on the lives and work of scientists such as Becquerel, Curie and Rutherford;

d) prepare reports on topics such as:

   i) nuclear weapons;

   ii) nuclear accidents;

   iii) breeder reactors;

   iv) nuclear medicine.

e) investigate and describe the effect of a magnetic field on tracks in a cloud chamber.

f) calculate yearly radiation dosage for citizens in the local community.

8. Some Teaching Suggestions

a) If the necessary equipment such as geiger counters are not available in the school perhaps they could be borrowed from colleges, universities or industry.

b) Field trips to colleges, universities or industry would also allow students to have the opportunity to discuss topics on nuclear energy with people working in the field.

c) Many films, filmstrips, and other audio-visual materials, along with other resources, should be used to illustrate and supplement concepts.

d) Speakers involved in the various aspects of the nuclear industry can bring up-to-date information to the students about the technology and associated career opportunities.

e) Students could visit a nuclear medicine facility at a local hospital.

Applied Physics, Grade 12, General Level (SPA 4G)

Optional Unit 3: Properties of Solids Time: 10 h

Whenever something is made, suitable materials must be chosen based on the intended use of the item. The properties of materials to be considered include density, strength, hardness, elasticity and thermal expansion. These characteristics would influence the design of items including their shape.

Much technological progress has come from the discovery and application of new materials, such as ceramics, plastics and synthetic fibres. A wide variety of innovative and inexpensive goods has resulted.

This unit may be divided into topics such as the following:

- Hooke's law
- Elasticity of materials
- Strength of materials
- Structural strength and shape
- Centre of mass
- Density of solids
- Thermal expansion of solids

Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation that many factors affect the design of materials (3b-3g);

b) an appreciation of the need for testing materials and products prior to their introduction or use (3b, 3d, 4b);

c) a curiosity into how materials are tested.

Skills. Students will have the opportunity to develop skill in:

a) observing and recording changes in materials under stress (2a-2d);

b) drawing charts and graphs to record experimental data (2a-2d);

c) using graphs to obtain information such as a spring constant (2a-2d);

d) following instructions to conduct experiments (2);

e) controlling variables such as the amount of bending with different structural shapes (2a-2d, 2g);

f) calculating the slopes of straight line graphs (2a, 2c);

g) using calipers to measure the dimensions of objects (2f);

h) measuring volumes of irregular solids by the displacement of water (2f);

i) making simple calculations to determine the density of materials (2f).

Knowledge. Students will be expected to:

a) explain terms such as elasticity, elastic limit, breaking point, shear, tensile, compression and torsion (2a-2d);

b) state Hooke's law (2a);

c) describe changes in the shape of a material or in the assembly of a structure that will increase its load-bearing ability (2d);

d) define centre of mass and explain how it can be determined (2e);

e) describe the conditions that could cause an object such as a boat to roll over (2e);

f) define density (2f);

g) explain thermal expansion of solids and account for different rates of expansion for different materials (2g);

h) describe application where specific physical properties of solids are used (2).

Student Activities

Students are to:

*a) measure the change in length of springs when subjected to different forces; graph applied force (F) versus change in length (Δl); determine the slope of the F vs Δl graph (6a, 8a);

*b) measure the change in length of various elastics, plastic bags or other materials when more and more masses are suspended from or added to the item, perhaps to a breaking point and graph applied force (F) versus change in length (Δl) to compare the results and compare with handbook data for different materials (6a, 8a);

*c) observe and measure the bending in a metre stick or hacksaw blade clamped to the desk on one end and acted upon by known forces at the other end; graph the amount of bending measured against the applied force (6a, 8a);

*d) construct, out of sheet metal or bristol board, beams of various shapes from identical strips of material; test the beams for structural stiffness and strength by measuring the amount of bend when subjected to known forces (clamp to the desk at one end and apply masses to the overhanging part of the beam); graph the data obtained from this activity on one graph to show the relative strengths of each shape; compare the bending of each beam with that of an unshaped strip of metal (6a, 8b, 8c);

*See the subsection entitled "Student Activities" on page 7.

*e) determine the centre of mass of various shapes by suspending these shapes from different points (8d)

*f) determine the volume of various materials either from direct measurements (the use of calipers should be encouraged) or by the displacement of water and determine the density of the material after a mass determination has been done.

3. Applications

a) Elasticity of materials is the basis for measuring forces using spring scales.

b) Compressing, stretching or twisting materials past their elastic limit allows the shaping of objects such as car fenders and bumpers.

c) The structural strength of a beam is affected by its shape. For example, holes are cut into structural members of aircraft wings to make these parts lighter without sacrificing appreciable strength because the shape is not changed.

d) Load-bearing trusses and beams in bridges and walls have cross-bracing parts arranged to form triangles to resist deformation.

e) Synthetic fibres have aesthetic appeal and great strength and elasticity. These properties make synthetic fibres suitable materials for clothing.

f) Sound-proofing qualities of materials are related to density and elasticity. Denser, inelastic materials are better for sound proofing.

*See the subsection entitled "Student Activities" on page 7.

g) Expansion joints are put in structures such as bridges to allow for thermal expansion and contraction.

Societal Implications

a) Our standard of living is influenced by the availability of strong, yet relatively inexpensive materials for clothing, shelter, transportation, and communication.

b) The use of revolutionary construction materials or processes which make construction easier or goods more durable could have massive effects on employment and therefore the economy.

Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) ability to measure accurately with appropriate instruments;

b) laboratory records and reports;

c) preparation and interpretaions of graphs;

d) ability to follow instructions for conducting activities.

Safety Considerations

a) Suspended masses should be affixed firmly and protective materials placed below them so that no damage would be done to the floor or to the feet if a mass were to fall.

b) If steam is generated and passed through hollow rods to show thermal expansion, the generating apparatus should be checked for proper assembly and operation.

c) A materials testing apparatus should be used only under specified, safe operating procedures.

7. Possible Extensions

Some students might:

a) investigate the effect of various cross bracing designs on the rigidity and load-bearing capability of a structural design;

b) examine domes, arches, and flying buttresses, in architectural designs to show how each design contributes to structural strength;

c) become involved in constructing models of buildings and bridges to be compared for structural strength;

d) present a report on a topic such as:

- Metal fatigue;
- Geodesic structures and designs;
- Pre-stressed concrete and some applications;
- Non-destructive testing techniques.
- Composite materials
- Selection of appropriate materials for specific needs.

8. Some Teaching Suggestions

a) Springs as well as other materials with different elasticities should be used by different students to allow for comparisons.

b) Bridge designs as well as building designs can be demonstrated in the classrooms by films, videotapes, or computer.

c) The sheet metal shop , the woodworking shop, or the mechanical drafting laboratory in the school or perhaps locations in the local community could provide shaped metal or wood beams for the student activity on structural strength. Students could specify the shapes desired.

d) A variety of toys and other items are designed to operate with centres of mass in unusual locations.

Optional Unit 4: Time

Time: 10 h

Time is an idea that is difficult to express in scientific terms, yet we all know what time is from experience. We can all measure "bits" of time because clocks are all around us. Our bodies contain several clocks, one being the heart. For accuracy we depend on mechanical and electrical clocks. Historically, civilizations developed early clocks called calendars from astronomical observations.

It is recommended that if this unit is selected that it be studied at the beginning of the course.

This unit may be divided into topics such as the following:

- Astronomical clocks
- Biological clocks
- Mechanical clocks

Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation for the idea that time cannot be easily defined scientifically, yet it can be measured with great precision;

b) an appreciation for the idea that the measurement of time has historically been of great importance and continues to influence our daily activities (3a, 4a, 4c);

Skills. Students will have the opportunity to develop skill in:

a) collecting and recording data from measurements needed to determine the period of a pendulum (2b);

b) making predictions of possible outcomes for pendulum experiments (2d);

c) determining the period and frequency of events using a stop watch and an electronic or hand stroboscope (2a, 2c-2e);

d) controlling variables such as length when determining the period of a pendulum (2d);

e) determining their pulse rate (2a);

f) calibrating tape timers and using them to measure time (2f);

g) using a stopwatch to measure time (2a, 2b-2d).

Knowledge. Students will be expected to:

a) define period and frequency as they relate to time and state the symbols and units for each (2b-2e);

b) state the relationship between period and frequency (2b, 2c);

c) identify some factors affecting the period and frequency of a pendulum and a bobbing spring (2d);

d) define the units of time we call day, month, year with respect to astronomical events;

e) describe how a flashing strobe can be used to determine the frequency of rapid, regular motion (2e);

f) describe several examples that illustrate the existence of biological clocks in nature;

g) explain why the pulse rate cannot be used as a standard time unit (2a);

h) state the relationship between the period of a vibrating spring and the mass attached to it (2d).

Student Activities

Students are to:

*a) determine their pulse rate when at rest and after some activity and also their reaction time from a visible stimulus to a physical reaction (6a, 8c);

*b) determine the period of a vibrating pendulum (8a, 8b);

*c) determine the frequency of a vibrating spring (8a, 8b);

*d) determine the relationship between period and i) attached mass, ii) amplitude, iii) length, of a vibrating spring or pendulum (8a, 8b);

e) use a flashing strobe to determine the period and frequency of short-timed events (6b, 8d);

*f) calibrate a tape-timer and use it to determine the time for an object to fall a distance;

*g) determine their reaction times by grasping a metre stick, released from hand level using distance as a measure of time.

Applications

a) The pulse rate is used to monitor medical conditions.

b) All clocks utilize a motion which accurately repeats itself inside the clock.

c) Stroboscopic effects are seen in motion pictures and in the electron sweep of a TV picture tube. Automobile mechanics use electronic strobes to adjust the timing mechanism in engines.

Societal Implications

a) Religious holy days are determined by a calendar.

b) Navigation has depended upon good chronometers for determining

*See the subsection entitled "Student Activities" on page 7.

accuracy of position.

c) Precise time measurements control the electronic media with rigid schedules.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) collection and organization of experimental data;

b) laboratory investigation reports.

6. Safety Considerations

a) Strenuous physical activity should not be undertaken by students having known medical problems.

b) Beware of epileptic students viewing flashing strobe lights.

7. Possible Extensions

Some students might:

a) obtain information comparing pulse rates of smokers and nonsmokers, and these comparisons could be used to discuss the principles of statistical sampling, such as, the principle that the sample should be very large;

b) explain why the wheels of a stage coach in western movies seem to go backwards, or how movies and time-lapse photography work;

c) investigate:

- solar and lunar eclipses;
- calendars and calendar reforms;
- the universal calendar;
- migration of birds and animals (biological clocks).

d) design and construct a water clock.

Some Teaching Suggestions

a) Tables and graphs should be used whenever appropriate to organize data.

b) Most of the activities should be done in pairs to ensure maximum participation.

c) When determining pulse rate, the student should count pulses over a time span of 20 to 30 s and then determine the period of the pulse.

The period of pulse for every student should be shown on a bar graph so that the suitability of the pulse as a timing device (clock) can be determined. Make separate graphs for the pulse rate when at rest and again after strenuous activity.

d) Hand strobes could be useful to slow down and "freeze" short-lived events. The "look frequency" can be increased by either a faster rotation of the strobe or by increasing the openings in the strobe. Mechanical strobes give more constant speeds of rotation. Flashing strobes can be regulated to flash at different frequencies.

e) Clocks exist in nature. Those used by all civilizations are:

(i) the daily motion of the sun across the sky;

(ii) the near monthly motion of the moon around the earth;

(iii) the yearly motion of the earth around the sun.

The position of sun and/or stars and the appearance of the moon have given rise to the concepts of day, month, year.

Applied Physics, Grade 12, General Level (SPA 4G)

Optional Unit 5: Distance: Measurement and Applications Time: 16 h

To say that an object is big, or that a destination is far away does not give us specific information. More precise descriptions would be "the object is seven metres tall" or "the destination is twenty kilometres away". Today's technology is capable of measuring items from the size of atoms to the distances to galaxies.

Distance measurements are often used to infer other things as well. In traffic accidents, for example, the length of the skid marks is used to estimate the speed of the vehicle(s). The twist in a steel beam can be used to measure the magnitude of the forces that were involved.

This unit may be divided into topics such as the following:

- Indirect measurement: triangulation and scale diagrams
- Precision: calipers and micrometer
- Applications: area and volume
- Resultant displacements: vector addition

Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation for the importance of precise measurements (2);
b) a realization that the ability to measure precisely has been improved by developments in technology (2b-2d);
c) a realization that indirect measurements are useful (2a, 3a).

Skills. Students will have the opportunity to develop skill in:

a) estimating distances, large and small (2a);

b) constructing scale diagrams to solve problems involving distance (2a);

c) making calculations using data obtained from scale diagrams (2a, 2f);

d) using instruments such as a ruler, protractor, micrometer, calipers and calculator (2a-2e);

e) calculating the area and volume of regular objects (2d);

f) using vector diagrams to determine resultant displacements (2e);

g) using vector addition to solve problems (2e).

Knowledge. Students will be expected to:

a) determine by triangulation distances not directly measureable (2a);

b) decide when calipers and micrometers are suitable instruments for distance measurements (2b, 2c);

c) convert measurements of length from mm to cm to m to km, and vice versa (2a-2e);

d) write and correctly use the formulas for determining the area of regular surfaces and the volume of rectangular and cylindrical solids and a sphere (2d);

e) distinguish between vector and scalar quantities and between displacement and distance (2e, 2f).

2. Student Activities

Students are to:

*a) estimate and use triangulation and scale diagrams to measure distances that cannot be measured directly or conveniently;

*See the subsection entitled "Student Activities" on page 7.

*b) measure distances with precision using Vernier calipers and/or micrometers;

c) construct Vernier calipers from cardboard and use these for making measurements;

*d) measure the approximate thickness of a molecule (8e, 8f);

*e) draw scale diagrams to find resultant displacement;

f) draw scale diagrams to predict the net force on objects at rest and to verify these predictions using a force table (8f).

Applications

a) Surveyors and astronomers use the principles of triangulation.

b) People in the construction and manufacturing industries must make and use precise measurements.

Societal Implications

a) Technology depends on the ability to make accurate, reproducible measurements.

b) Making measurements directly or indirectly is important in the construction industry. Inaccurate measurements lead to inferior products.

c) Making precise measurements requires sophisticated measuring devices and people with training to use them.

Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) facility with, and understanding of distance-measuring techniques, including the use of scale diagrams;

*See the subsection entitled "Student Activities" on page 7.

b) accuracy in making distance measurements;

c) use of vector diagrams to determine resultant displacements.

6. Safety Considerations

7. Possible Extensions

Some students might:

a) Investigate archaic units of measurement and indicate how such units were defined.

b) Define the metre precisely indicating how the definition has changed throughout history.

c) Recognize the existence of "errors" in measurement and identify the causes of such errors. The use of significant digits is a way of expressing precision in measurement.

d) Build and use instruments such as rangefinders, torsion balances, and gravitometers.

e) Investigate the relationship between surface area and volume in determining the optimum size and shape of objects and living things.

d) Build three-dimensional scale models to make measurements, for example, in determining the path, speed, and height of a meteor.

8. Some Teaching Suggestions

a) Examples of optical illusions may be illustrated and students can judge which objects or lines in the illusions are larger or longer. The students should then verify each judgement by direct measurements. The measurements should be expressed in mm, and in cm, and in m. Students should be encouraged to choose appropriate units for each type of measurement. For example, the size of a page is best expressed in cm, and the

distance to Vancouver in km.

b) Roadmaps and/or contour maps may be used to enhance activities involving scale diagrams or displacement.

c) Students should make their own astrolab and then use this instrument to measure the height of structures outside the classroom and outside the school. Similarly, rangefinders can be built by students and used to measure distances to structures or buildings. Such activities are ideal for a field trip outside the school.

d) Overhead transparencies with overlays can be used to show the principle of vector addition.

e) The concepts of area and volume should be reviewed prior to the "Thickness of a Molecule" experiment. Transparencies of metric graph paper can be used as overlays to count the squares found within a regular shape. Comparisons between the values obtained by counting squares and values obtained from equations of area should be made.

f) The "Thickness of a Molecule" experiment using lycopodium powder and oleic acid should be preceded with a demonstration showing that volume is conserved. For example, a box full of marbles or ball bearings can be emptied onto a table or floor and packed into rectangular shapes, one marble or ball bearing thick. The space (volume) occupied by the marbles or ball bearings should be compared in each case.

g) A contest can be held to guess the number of marbles or ball bearings which would fill a rectangular container. The students should be allowed to make measurements which would enable them to derive an answer.

h) Scale diagrams and a force table can be used to show and to verify the principles of vector addition.

Applied Physics, Grade 12, General Level (SPA 4G)

Optional Unit 6: Locally Designed Unit Time: 10 h

This unit is to be designed at the local level as desired. It can be used to introduce a new area or topic of science not described in this guideline or to incorporate additional objectives that will expand a previous part or parts of the course. The time chosen for this unit should be such that when combined with the other opional units a total of 30 h is allocated. Examples of new areas or topics that might be considered include:

Colour
Careers in physical science
Machines
Physical properties of matter
Physics of the human body
Basic electronics
Basic astronomy

This unit may provide an excellent opportunity for students to engage in independent study on a topic in physics that is of particular interest and that is approved, monitored, and evaluated by the teacher. Students may work individually or in small groups. Care should be taken to not allow the work to overlap with subject matter in other science courses that the students are likely to take. The unit could be started after the students have had some experiences in the laboratory and are well aware of accident prevention. If a series of short topics are considered they may be fitted into the course schedule from time to time throughout the semester or year.

It is expected that the local design of this unit will incorporate components similar to those adopted in the core units, namely, objectives, student activities, applications, and societal implication. An outline of the unit is to be included with the school's course of study and kept on file so that it is available to interested students and parents.

Particular Features of the Grade 12 Technological Science Course

Units of Study and Their Time Allocations

The following chart provides an overview of the units of study in this course and indicates the time to be allocated to each unit.

Technological Science, Grade 12, General Level (STE 4G)

Units	Time Allocations
Core	
1. Chemical Language and Calculations	12 h
2. Thermochemistry	12 h
3. Chemical Analysis	17 h
4. Kinematics	12 h
5. Kinetics	12 h
6. Statics	12 h
7. Fluids	13 h
8. Machines	7 h
	97 h
Optional - Choose one of	
1. Materials	13 h } 13 h
2. Locally Designed Unit	13 h }
	110 h

This course is designed to enable students at the general level to have an opportunity to develop skills in various applications of technology and also to prepare them for technological diploma courses offered at the colleges of applied arts and technology.

The emphasis in this course is on pragmatic and applied rather than philosophical and abstract reasoning. Students will have opportunities to improve their skills in measuring accurately and using equipment and instruments appropriately. Through the use of various instruments, the limitations of the accuracy and precision of the measurements taken will be indicated. Opportunities be improve skills in the areas of data collection, organization, interpretation, and communication will also be provided.

The course is designed to build upon the knowledge and skills acquired in the Applied Chemistry and Applied Physics courses. Teachers should be familiar with the content of these courses so that this course will complement previous studies.

The optional unit, entitled "Locally Designed Unit", may be used to introduce a new area of technology not described in the guideline, to include new work that expands on previous topics in the course, or to extend the time allocations for the core units by an additonal 13 hours.

In Part 1 section 8.2 of this guideline, there is a list of metric units with which the students are expected to be familiar by the end of Grade 10. In Senior Division courses, the list of metric units with which science students work will naturally expand. Metric units are preferred and should always be indicated, however, in some areas non-metric units may be still in general use and should be indicated.

Grade 12 Technological Science Course

Core Units:

1. Chemical Language and Calculations
2. Thermochemistry
3. Chemical Analysis
4. Kinematics
5. Kinetics
6. Statics
7. Fluids
8. Machines

Optional Units:

1. Materials
2. Locally Designed Unit

Technological Science, Grade 12, General Level (STE 4G)

Core Unit 1: Chemical Language and Calculations Time: 12 h

Formula writing and equation writing constitute a part of the language of chemistry. These universal formulas and equations should be understood by those working with chemicals.

From formulas and balanced chemical equations, engineers, scientists,technologists, technicians, and manufacturers are able to predict products, calculate yield, and determine the profitability of many chemical processes.

This unit may be divided into topics such as the following:

- Chemical names and formulas
- Combining capacity (valence)
- Writing and balancing chemical equations
- Atomic masses and formula masses
- The mole
- Chemical calculations

Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation of the global use of chemical language (3b);
b) an interest in the value of equations in predicting the quantities of raw materials needed (3a, 3b);
c) a curiosity about the chemical composition of everyday substances (3e, 4b);
d) a commitment to conservation of raw materials (3d).

Skills. Students will have the opportunity to develop skill in:

a) writing formulas and naming binary compounds and compounds containing common anions such as halides, oxides, sulphides, hydroxides, nitrates, sulphates, carbonates, and cations such as ammonium, alkali metals, alkaline earth metals, and several other elements such as copper, iron, and aluminum (2);

b) calculating gram molecular masses and using these to calculate the number of moles or the mass of chemicals needed in a reaction (2);

c) performing calculations involving chemical equations and chemical formulas (2);

d) handling apparatus and laboratory equipment correctly and safely (2);

e) measuring, appropriate to the equipment used, and recording experimental data accurately (2);

f) calculating a theoretical yield from a balanced chemical equation (2c, 2d).

Knowledge. Students will be expected to:

a) state the names and symbols of at least 30 elements (2, 8a);

b) state the meaning of combining capacity (valence) of an element (2, 8a);

c) write formulas for, and state the names of binary compounds, and compounds containing polyatomic ions, using valences and the periodic table for assistance (2, 8a);

d) demonstrate an ability to balance simple chemical equations involving reactions encountered in the unit (2);

e) define and give examples of atomic mass, formula mass and the mole (2);

f) use the mole concept to solve simple stoichiometric problems (2);

Student Activities

Students are to:

*a) carry out an experiment to determine the molar relationship between two substances in order to emphasize the mole concept and to provide the basis for writing equations, for example, an iron nail in a copper bromide solution or solid copper immersed in a water solution of silver nitrate (6a, 6b, 6d)

*b) carry out an experiment to prepare a solution of given molar concentration and to use this solution in a quantitative determination of the number of moles involved in a reaction (e.g., iron - copper chloride reaction);

*c) perform an experiment to determine the experimental yield of a reaction in moles and by mass (e.g., the burning of magnesium or the heating of copper carbonate). Calculate the theoretical yield for the reaction and compare this to the actual yield (6c);

d) decompose bluestone and calculate the percent of water by mass in the crystal.

Applications

a) Chemical processes can be made more efficient as product yields are determined and profitability predicted.

*See the subsection entitled "Student Activities" on page 7.

b) Equations are part of the language of chemists in communicating the results of reactions. Equations may be used to help explain many household and industrial processes.

c) Quality control of foods, drugs, and cosmetics is partly dependent on a knowledge of chemical reactions.

d) Recovery of valuable metals from solution can be done using displacement reactions.

e) Water softeners rely on chemical reactions.

4. Societal Implications

a) Common or trade names for substances may not indicate details of their composition, whereas chemical names tend to be more meaningful. Different brand names may be used to sell the same chemical product at different prices.

b) Society must find safe means of disposing of some of the by-products of large-scale chemical reactions.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) facility with, and understanding of process skills;

b) laboratory reports of activities;

c) laboratory skills as demonstrated during the performance of the unit activities;

d) practical laboratory tests.

6. Safety Considerations

a) Students should be cautioned that many chemicals are harmful if not properly used. Students should keep chemicals away from

their mouth and should wash their hands after handling chemicals.

b) Students should tie back long hair and use safety goggles and aprons when appropriate.

c) Students should not look directly at burning magnesium.

d) Students should be taught to exercise care when handling silver nitrate as it stains the skin.

Possible Extensions

Some students might:

a) prepare a compound by more than one method, calculating the experimental yield, and comparing the yields for the different methods used;

b) do an analysis of class experimental data (e.g., error analysis);

c) carry out a quantitative determination of the sulphur dioxide content in various foods;

d) carry out a quantitative determination of the mineral content in milk;

e) write a brief report on the value of balanced chemical equations to a chemical manufacturer;

f) write a brief report on the contribution of some chemist such as Lavoisier, Dalton, Mendeleev, Curie, Pauling, Herzberg, Bartlett, Polanyi to our present chemical knowledge.

Some Teaching Suggestions

a) As many elements and compounds as is practical should be displayed when students are learning names, symbols and valences.

b) Films such as the Chem Study film "Families of Elements" can be shown.

c) Students should be supplied with ion charts for tests and examinations. Understanding and use rather than rote memory should be emphasized.

d) This unit should be experimentally based. The intent of this unit is to enable students to achieve skill in experimental work.

Technological Science, Grade 12, General Level

Core Unit 2: Thermochemistry Time: 12 h

All matter contains stored energy which can be released as heat. Heat is one of the most important forms of energy, and it is not only necessary to maintain life but also to supply major energy requirements for our rapidly expanding technology. Thermochemistry, is the study of the heat involved when materials undergo either physical or chemical changes.

This unit may be divided into topics such as the following:

- Temperature and heat
- Effects of heat on matter
- Heats of reaction
- Additivity of reaction heats and conservation of energy

Objectives

Attitudes. Students will be encouraged to develop:

a) appreciation of the importance of heat energy in supplying the major energy requirements for our rapidly expanding technology;
b) respect for the advances made in applying physical and chemical concepts and the impact these applications have on society;
c) commitment to conservation of energy resources;
d) respect for accuracy and precision in measurements (2a).

Skills. Students will have the opportunity to develop skill in:

a) measuring temperature and mass and calculating the specific heats of different substances (2a-2c);

b) using different kinds of temperature measuring devices (2a-2e);

c) determining volume, thermal expansion, and heats of reaction of different substances (2b, 2e);

d) deriving from experimental data the law of additivity of heats of reaction (2e);

e) classifying changes as physical, chemical, or nuclear and relating the approximate energy changes that would be involved (2d, 2e).

Knowledge. Students will be expected to:

a) differentiate between temperature and quantity of heat (2a, 2c);

b) describe the construction and explain the operation of some temperature measuring devices (2a);

c) compare and contrast the advantages and disadvantages of different types of thermometers (2a);

d) define or correctly use the terms linear, surface and volumetric expansion (2b);

e) define specific heat, exothermic and endothermic reactions, and heat content (enthalpy) (2c-2e);

f) identify exothermic and endothermic reactions by their laboratory characteristics (2d);

g) state and apply Hess' law and the law of conservation of energy (2e);

h) recall that energy is involved when bonds are broken or new bonds are formed (2e);

i) be aware of the relative amounts of energy involved in physical,chemical and nuclear reactions (2e);

j) identify several careers associated with an understanding of thermochemistry.

Student Activities

Students are to:

a) measure accurately the temperature of different substances using different kinds of temperature measuring devices such as a liquid-in-glass thermometer, a dial thermometer, a resistance thermometer, and a thermocouple thermometer;

b) measure the linear, surface and volumetric expansion of some solids and liquids (6d);

*c) determine experimentally the specific heat capacity of various solids using a calorimeter;

d) determine the energy effects of dissolving (both exothermic and endothermic) using, for example, sodium hydroxide and ammonium nitrate (6c);

*e) conduct simple experiments to derive Hess' law such as the reaction between sodium hydroxide and hydrochloric acid (6c).

Applications

a) Gas thermometers are useful at very low temperatures. Dial thermometers are ideal for many industrial purposes. Resistance thermometers are well suited for measuring high temperatures (up to 1350°C) and are used for heat-treating and annealing processes in the metallurgical industry. The very small size of thermocouple thermometers make them convenient to determine

*See the subsection entitled "Student Activities" on page 7.

accurately temperatures inside pipes, stacks, furnaces, cylinder heads.

b) Allowance must be made for expansion and contraction in structures exposed to outside temperature variations (e.g., steel rails are laid with gaps between the ends to allow for expansion due to temperature changes, bridges are built on rollers or rockers, power lines are strung with a certain amount of slack, large masonry walls need vertical expansion joints filled with flexible caulking).

c) The importance of changes of state to industry should be emphasized (e.g., refining metals and petroleum).

d) An understanding of the properties of gases helps explain the working of such products as air pumps and aerosol spray cans. Gases are used in transportation as a supporting medium (hot air balloons, dirigibles, tires) and as a means of propulsion (the combustion engine, the rocket engine).

e) The thermite reaction generates sufficient heat to raise the temperature of the iron produced above its melting temperature, before the heat is conducted away.

f) Electric generating power plants use energy from physical, chemical, or nuclear reactions.

4. Societal Implications

a) Conservation of energy and the development of alternate energy sources such as solar energy will become even more important as supplies of conventional fossil fuels dwindle.

b) Future homes and buildings will show innovative heating and cooling systems.

c) The use of heat energy has improved our life style and is crucial to our personal as well as our technological survival.

d) Pollutants from heat engines pose serious health hazards and environmental problems.

e) Heat pollution of rivers and lakes is cause for concern in some parts of the globe.

f) Energy supplies from fossil fuels are being depleted, resulting in industrial societies becoming increasingly dependent on nuclear energy. This may replace an "acid rain" problem with the problem of storage of nuclear wastes.

g) The preservation of materials by removal of heat has had a great impact on society (e.g., frozen foods, blood banks, seminal banks for livestock breeding).

Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) experiments and laboratory reports;

b) practical lab tests.

Safety Considerations

a) The use of mercury thermometers should be avoided.

b) Precautions should be taken when handling glass tubing and inserting thermometers into rubber stoppers.

c) Students should be given instrucrions in the use of solutions that may be poisonous, reactive, or corrosive. Liquids and solids should be kept away from the mouth, hands should be washed after working with chemicals, and loose hair or clothing should be tied back.

d) Safety goggles should be used when heating solutions.

e) The thermite reaction should only be done as a demonstration experiment.

7. Possible Extensions

Some students might:

a) research the use of optical pyrometers in measuring very high temperatures;

b) investigate the use of ultraviolet and infrared spectrophotometers and indicate the principles upon which they are based;

c) demonstrate various experiments that indicate the anomalous behaviour of water;

d) perform experiments to show the different factors which affect the boiling point of a substance;

e) study the energy involved in fission and fusion reactions. Mention should be made of Einstein's relation of mass, energy and velocity ($E= mc^2$);

f) investigate how chemical hand warmers function;

g) perform experiments to determine the heats of dilution;

h) research the advances in livestock breeding during the decade and comment on the value of artificial insemination (as facilitated by sperm banks);

i) compare and contrast the cooking of eggs and potatoes in microwave and conventional ovens.

j) investigate the significance of absolute zero, and note some of the difficulties in attaining this temperature.

Some Teaching Suggestions

a) When doing the unit on thermometry, activities should be student oriented. When the equipment available is limited groups of students can be rotated around laboratory stations, each set up with equipment for a particular laboratory activity.

b) The usefulness, accuracy, range and span of each type of thermometer should be discussed.

c) In writing chemical equations it should be stressed that it is important to indicate the states (solid, liquid, gas or solution) of each reactant or product.

d) The phrase "heat content" may be preferred in place of enthalpy. Energy units in kilojoules are preferred.

e) Comparisons between the magnitudes of energy released in physical, chemical, and nuclear reactions should be indicated.

Technological Science, Grade 12, General Level

Core Unit 3: Chemical Analysis Time: 17 h

Chemical analysis deals both with the identification of and the amount of different substances found in a sample. This unit makes the student aware of some of the techniques of analytical chemistry and provides an opportunity to carry out laboratory activities aimed at solving "unknowns".

There are many industrial applications of chemical analysis including the steel industry, the oil industry, and the food processing industry. As well, chemical analysis is critical to successful pollution control and to successful quality control of pharmaceuticals. Chemical analysis plays a prominent role in forensic science.

Practically everything we eat, drink, or wear has been subjected to some type of chemical analysis.

This unit may be divided into topics such as the following:

- Qualitative analysis
- Gravimetric analysis
- Analysing solutions
- Chromatographic analysis
- Instrumental analysis
- Careers in analytical chemistry

Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation of the usefulness of chemical analysis

for quality control in all industries including food and pharmaceuticals (3a, 3d, 3e, 4a, 4d);

b) an interest in the importance of chemical analysis in such areas of study as pollution control and forensic science (3b, 3c, 4b, 4d);

c) self-confidence in their analytic skills (2d, 2e);

d) an open-mindedness to challenge the evidence and inferences of investigative work (3, 8c);

e) respect for accuracy and precision in measurement (3).

Skills. Students will have the opportunity to develop skill in:

a) following written and oral instructions to determine the presence and quantity of a substance in a given sample (2b-2e);

b) manipulating laboratory apparatus properly and safely (2b-2h);

c) noting the accuracy limitations of laboratory equipment (2b-2h);

d) summarizing observations in tabular form (2b-2h);

e) communicating laboratory findings effectively (2b-2h);

f) problem solving using an investigative approach (2);

g) gaining familiarity with analytical procedures (2b-2h);

h) solving percentage composition problems (2b-2d);

i) researching and report writing on the careers related to chemical analysis (2a).

Knowledge. Students will be expected to:

a) define or state the meaning of the following: gravimetric, volumetric, chromatographic;

b) explain how a flow chart may be used to organize analytic methods (2b-2d);

c) distinguish between an observation and an inference (2b-2h, 8c);

d) use an analysis scheme to determine the presence or absence of substances in a sample (2b-2e);

e) explain how chemical and physical properties affect the type of analytic techniques used (2b-2h);

f) identify several careers that require a knowledge of chemical analysis (2a).

Student Activities

Students are to:

*a) prepare an oral or written report, based on library research or interviews, outlining the wide range of careers that are involved in chemical analysis;

b) analyse quantitatively a metal pollutant in water or analyse quantitatively a sample for a suspected contaminant (6a, 6b);

c) determine the iron content in certain food samples (6a, 6b);

*d) perform a gravimetric determination of copper, cobalt, nickel or zinc (comparable experiments can be substituted for the above, such as to determine the percentage of phosphate ion present in a phosphate sample) (6a, 6b);

*e) carry out a volumetric analysis such as the determination of the amount of vitamin C in several consumer products or the amount of calcium and magnesium in a milk sample using EDTA (6a);

f) carry out a solvent extraction such as the removal of iodine from a solution (6a, 6c);

*See the subsection entitled "Student Activities" on page 7.

g) perform a simple and a fractional distillation such as the separation of water and a solute (6e);

*h) perform one of paper, column, or thin-layer chromatographic separation. Examples can include paper-analysis of inks and dyes, column-separation of leaf pigments, analysis of lubricating oil, or thin layer-separation of amino acids.

3. Applications

a) Quality control of food, drugs, and cosmetics depends on chemical analysis.

b) Identification of substances in forensic science may help solve crimes.

c) Environmental studies rely on chemical analysis to identify pollutants and contaminants.

d) Chemical analysis is fundamental to many industrial processes (e.g., the steel and oil industries).

e) Chemical analysis is the basis of the diagnosis of many diseases (e.g., urine analysis for diabetes mellitus).

4. Societal Implications

a) Without quality control standards, based on chemical analysis, society would be subjected to products with widely varying degrees of purity.

b) Forensic scientists use chemical analysis in gathering and analyzing evidence for criminal investigation.

c) The medical profession relies on many chemical analyses for accurate and rapid diagnosis.

*See the subsection entitled "Student Activities" on page 7.

d) Swimming areas and pools and drinking water supplies are continually tested for contaminants.

Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) successful identification of unknowns;

b) laboratory skills;

c) practical laboratory tests;

d) laboratory reports;

e) library research.

Safety Considerations

a) Students should be warned that many chemicals are harmful. Students should keep chemicals away from their mouths and always wash their hands after handling chemicals.

b) Students should tie back long hair and use safety goggles and aprons.

c) Particular care must be taken with certain materials that might be used in this unit (e.g., iodine, nitric acid).

d) Care must be taken when using open flames.

e) Precaution must be taken when working with distillation apparatus.

Possible Extensions

Some students mights:

a) visit a forensic science laboratory;

b) collect water samples from a number of sources and analyze them;

c) visit a quality control laboratory;

d) investigate gas-liquid chromatography;

e) investigate various instruments used in analysis (e.g., infrared, ultraviolet, nuclear magnetic resonance);

f) supplement the solvent extraction of iodine from a solution activity, by using a colorimeter and plotting an absorption curve;

g) collect and analyse air samples from a number of sources;

h) analyse a sample of tears.

8. Some Teaching Suggestions

a) This unit is based on student activities and therefore theoretical work should be kept to a minimum.

b) A variety of problem solving settings may be devised to increase interest and relevance (e.g., forensic case studies can be devised for most analysis activities and Ontario ore samples can be used for metal analysis);

c) Emphasis should be placed on correct laboratory technique in arriving at accurate observations, measurements, and inferences rather than an emphasis on the understanding of chemical reactions involved.

d) Evaluation should be based primarily on activities and laboratory work rather than written tests.

e) If equipment is limited the laboratory exercises of this unit can be done as a set of rotary labs.

Core Unit 4: Kinematics

Time: 12 h

Kinematics is a study that breaks down the motion of bodies into components so that the motion can be analysed. The study of machinery, transportation, or the everyday world is greatly enhanced by the knowledge of the fundamentals of kinematics. With fast-moving machinery components, precision is essential; the study of kinematics demonstrates the need for precision. Modern robotics call for a greater knowledge of kinematics than was previously required.

This unit may be divided into topics such as the following:

- Kinematics equations
- Displacement
- Velocity
- Acceleration

Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation for the value of graphs and scale diagrams in illustrating motion and its results (3e);

b) a desire to measure precisely and record data accurately (3a, 3c-3e);

c) a respect for the validity of experimental data such as those used in determining automobile safe driving procedures (3a, 3c, 4a).

Skills. Students will have the opportunity to develop skill in:

a) measuring times and displacements (2a, 2d);

b) calculating average velocities and average accelerations (2a, 2b, 2d);

c) solving simple problems using kinematics equations (2a, 2d);

d) plotting data from experiments involving accelerated motion (2a, 2e);

e) determining slopes of displacement-time and velocity-time graphs (2a);

f) determining displacements from velocity-time graphs (2f);

g) interpreting graphs that depict motion (2a);

h) drawing vectors to represent displacement or velocity (2b, 2c);

i) using a scale diagram to determine resultant displacement and velocity (2b, 2c);

j) interpolating and extrapolating on a graph (2f).

Knowledge. Students will be expected to:

a) recall 1) the definitions of uniform speed, average speed and uniform acceleration (scalar) (2a, 2b);

2) the formula $V_{av} = \frac{d}{t}$ used to determine the average speed of a moving object (2b);

3) the formula $a = \frac{\Delta v}{\Delta t}$ to determine the average scalar acceleration of a moving object (2d);

4) the significance of the slope of a distance-time graph and speed-time graph (2a);

b) select the proper kinematics equation to solve a problem involving uniform acceleration in a straight line;

c) distinguish between i) distance and displacement; ii) speed and velocity (2a-2c, 2f);

d) describe what is meant by acceleration with constant speed and give examples;

e) state the relationship between displacement and time when velocity is constant (2a);

f) state the relationship between velocity and time when acceleration is constant (2a);

g) describe the acceleration of an object, given a velocity-time graph showing changing velocities (2a);

h) identify the information provided by the area under a velocity-time graph (2f);

i) given a displacement-time graph or velocity-time graph, describe the motion of the object (2a).

. Student Activities

Students are to:

*a) measure displacements over consecutive intervals for a non-uniformly as well as uniformly accelerated object and plot displacement-time and velocity-time graphs from the data (2a-2c, 8b, 8d);

b) determine, on a map, the total distance travelled and resultant displacement as well as average speed and velocity for one or more designated trips by aircraft between three locations;

*c) construct a scale diagram to determine the resultant velocity of an object such as an aircraft or boat acted on by a wind or current (8e);

d) design and conduct an investigation to determine the acceleration due to gravity for a falling object using the formula $g = \frac{v_f - v_i}{t}$ (6c, 8b, 8c);

*See the subsection entitled "Student Activities" on page 7.

e) use data obtained from a Driver Education text or manual and plot a graph of stopping distances for an automobile against velocities and interpolate and extrapolate values using the graph (8a);

*f) determine the displacement of an object given a simple velocity-time graph.

3. Applications

a) Consumer magazines often publish performance data on new automobiles including acceleration rates and stopping distances.

b) A knowledge of kinematics is required in the design of acceleration lanes of superhighway and airport runways.

c) Achieving increased speed is an on-going activity of racing car builders and drivers.

d) A knowledge of kinematics is employed in the design and programming of industrial robots.

e) Pilots and sailors use vectors in plotting flight plans and making navigational adjustments.

4. Societal Implications

a) An understanding of the relationship between stopping distances and vehicle speed may influence driving habits.

b) Computers can produce graphs and charts from data for analyses.

c) The fascination of many people with speed has contributed to the popularity of automobile and speed boat racing.

d) The development of faster modes of transportation has created a global village.

*See the subsection entitled "Student Activities" on page 7.

e) The concepts of displacement, velocity, and time are integral to many daily activities.

Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) plotting and analysis of graphs;

b) laboratory reports;

c) construction of scale vector diagrams.

Safety Considerations

a) Any road tests to obtain data should be performed away from well-travelled roads.

b) Students should warm up before performing tests on bicycles.

c) Students should be told not to lean on air tracks and air tables.

d) All electrical equipment should have appropriate safety approval.

Possible Extensions

Some students might:

a) investigate angular motion and/or curvilinear motion and compare it to rectilinear motion;

b) investigate and report on the effects as the speed of an aircraft approaches and exceeds the speed of sound.

Some Teaching Suggestions

a) In graphing exercises, students should select suitable scales so that as much of the graph as possible is used.

b) Students should be encouraged to use the number of significant digits that reflect the measuring devices used when recording and using data.

c) Students should be encouraged to suggest improvements in the experiments they conduct.

d) Analysis of realistic motion situations, if possible, should be conducted, rather than pure laboratory experiments. This will increase student motivation.

e) Students should be encouraged to construct scale vector diagrams as large as possible to improve accuracy of measured resultant displacements or velocities.

Core Unit 5: Kinetics Time: 12 h

Kinetics deals with force and motion. The concepts of force, work, energy and power, arising from the study of kinetics, are vital building blocks of engineering technology.

This unit may be divided into topics such as the following:

- Newton's laws of motion
- Coefficient of friction
- Work and energy
- Power

1. Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation of the importance of experimentation in developing an understanding of physical phenomena;

b) an appreciation of the significance of the law of conservation of energy in the design and operation of any mechanism or machine (3, 4c).

Skills. Students will have the opportunity to develop skill in:

a) measuring the mass of an object (2b-2e);

b) measuring the force acting on an object using a spring scale (2b-2d);

c) recording experimental observations accurately such as those involving the acceleration of different objects subjected to various forces (2a-2f);

d) organizing experimental data in appropriate tables (2b, 2c);

e) controlling variables in invetigating Newton's Second Law (2b).

f) solving simple problems using the equations

i) $F = ma$

ii) $\mu = F$

iii) $E_p = mgh = w$

iv) $\rho = \frac{W}{T} = \frac{E}{T}$

v) $E_k = 1/2\ mv^2$ (2b-2f).

Knowledge. Students will be expected to:

a) state Newton's first law and describe or explain situations where the law applies (2a);

b) express Newton's second law as a formula (2b);

c) state Newton's third law of motion and describe or explain situations where the law applies (2f);

d) define coefficient of friction (2c);

e) distinguish between static and kinetic friction (2c);

f) distinguish between potential and kinetic energy (2e);

g) differentiate between force of gravity and mass (2d);

h) state the formulas for calculating gravitational potential energy, and kinetic energy (2d, 2e);

i) state the relationship between work done and energy transformed (2e).

j) state the law of conservation of energy and identify the energy transformations that occur in the operation of a specific mechanism or machine (2e);

k) define power and state a formula for calculating it (2g).

. Student Activities

Students are to:

a) investigate several simple examples that illustrate Newton's first law of motion and record observations (6);

*b) investigate the relationship among force, mass and acceleration (6, 8a, 8c, 8e);

*c) determine the coefficient of static and kinetic friction for two surfaces in contact (8a);

d) determine the force needed to lift an object through a specific height and calculate the work done against gravity;

*e) investigate the relationship between the potential energy of a ball at the top of a ramp or grooved track and the kinetic energy the ball has as it rolls off the track onto a desk top or the floor. Explain differences in values (8c, 8d, 8f).

f) investigate several simple examples that illustrate Newton's third law of motion and record observations (8c);

*g) conduct an experiment to determine the power developed by a student or machine performing a task.

. Applications

a) The principles of kinetics are used in machine design (e.g., industrial robots).

b) The forces required to operate machinery can be reduced by designing components to be as light as serviceability will allow, (e.g., moves to lighter cars, materials used in rockets).

c) Pile drivers illustrate potential energy being transformed into work done. The same principle can be used to estimate the load that a given driven pile can support.

*See the subsection entitled "Student Activities" on page 7.

d) Wrecking balls transfer kinetic energy into work done.

4. Societal Implications

a) The use of seat belts in automobiles has been legislated in order to protect people during collisions.

b) The design of rides in amusement parks is based on the principles of kinetics.

c) Machinery is designed to employ the principles of kinetics as efficiently as possible in the completion of a task.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) set up, and performance of activities;

b) laboratory data analysis and reports;

c) performance on practical tests.

6. Safety Considerations

Care should be taken with experiments involving dropping masses.

7. Possible Extensions

Some students might:

a) compare from published reports the power ratings of automobiles and trucks;

b) build and launch model rockets;

c) construct and calibrate a spring balance to register force in newtons;

d) design, build, and test an elastic propelled cart for energy efficiency.

8. Some Teaching Suggestions

a) Observations that include numerical data should be recorded in tabular form.

b) Students should be given opportunities to formulate conclusions based on their experiments.

c) Whenever possible students should be provided with problems reflecting real life situations which vary from fairly easy to very challenging.

d) Students should be encouraged to suggest improvements in the procedure for experiments that were performed.

e) Several different kinds of apparatus such as an air table and tape timers could be used simultaneously by different groups to investigate Newton's second law.

f) Plastic rulers can be used to make grooved tracks for energy conversion experiments.

Core Unit 6: Statics Time: 12 h

In daily activities many structures are used. Bridges, buildings, roads, radio towers, railway tracks and tunnels are designed to remain stationary. People depend on these objects remaining at rest.

The purpose of this unit is to increase the student's understanding of how and why structures remain stationary despite the numerous forces that act upon them. This study is termed "Statics".

This unit may be divided into topics such as the following:

- Characteristics of a force
- Vectorial representation of a force
- Resultant forces
- Resolution of forces into components
- Moments of forces
- Resultant of a parallel force system
- Free body diagrams
- Reactions to a rigid body

. Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation that force systems can be solved graphically with sufficient precision for technical usefulness (3a);

b) an appreciation of the utility of statics in planning safe structures (3a, 4a, 4c).

c) an appreciation that graphical methods can give a visual representation of a force system and save time in calculations (3a-3c).

Skills. Students will have the opportunity to develop skill in:

a) using appropriate scales in drawing force vectors (2b);
b) drawing a line parallel and perpendicular to a given line using set squares and a pencil (2a);
c) determining graphically the resultant of two or more forces using the rules of vector addition (2b);
d) resolving graphically a given force into any two given directions perpendicular to each other (2a);
e) determining the resultant of a parallel force system (2c-2e);
f) drawing a free body diagram that represents the forces acting on a body (2b-2f);
g) solving simple problems involving moments of force (2c-2e);
h) reading a spring scale (2b, 2d-2f).

Knowledge. Students will be expected to:

a) describe in a static situation, the magnitude, direction and point of application of known forces (2b-2f);
b) represent known forces by suitable vectors (2b);
c) explain the terms resultant, and equilibrant (2b-2f);
d) compare in a static situation, the magnitude and direction of the resultant and equilibrant (2d-2f);
e) define moment of a force, and a couple (2c);
f) explain the principle of transmissibility of a force (2f);
g) describe the relationship between the torque (or moment) and the distance of the force from the axis of rotation (2c-2e).

2. Student Activities

Students are to:

*a) draw lines parallel and perpendicular to a given line using a 30° - 60° set square and a 45° set square (8a, 8b);

*b) determine the resultant of two forces using a force board; ascertain the direction of the resultant and equilibrant; verify the resultant using a graphical solution (8c);

c) investigate the principle of moments using masses hung from a balanced rod or metre stick (6, 8d);

*d) for several loads suspended from a horizontal rigid rod, i) find the single point from which the rod can be supported, ii) determine the force required to support the loaded rod and iii) verify the magnitude and position of the supporting force mathematically (6, 8e);

e) support a rigid rod by two spring scales attached to a frame; attach one or more loads to the rod at different positions and record the value on each spring scale; verify these values mathematically (6);

f) compare the reading on a spring scale attached to a mass by a cord when i) the mass is allowed to hang vertically ii) the scale is attached vertically to a rigid support and the cord and mass are hung over a pulley and iii) the scale is attached horizontally to a rigid support with the cord and mass over a pulley (6).

3. Applications

a) Statics is used to determine loads acting on structural members and on holding foundations.

*See the subsection entitled "Student Activities" on page 7.

b) Effects of static loading of structural components are often determined by computer.

c) The principle of moments has been utilized in the design of many common mechanisms and machines.

d) an equal arm balance operates on the principle of moments.

4. Societal Implications

a) Adherence to concepts of equilibrium in structural design prevents disasters.

b) Computer assisted design allows several design alternatives to be investigated when previously there may have been time to consider only one solution.

c) Many variations in architecture in recent years can be attributed to an understanding of the principles of statics.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) scale vector diagrams;

b) performing experiments;

c) laboratory reports.

6. Safety Considerations

Students should be advised that careful handling of equipment is necesary to prevent beams or masses from falling.

Possible Extensions

Some students might:

a) investigate how a cantilever is supported so that it will not rotate out of position;

b) observe structures supported by guy wires and describe the forces acting;

c) solve vector problems dealing with finding resultants and components of forces mathematically;

d) investigate the conditions for equilibrium of a point.

Some Teaching Suggestions

a) Sufficient opportunities should be provided for students to become proficient in reading drafting scales and protractors, drawing lines parallel to a given line using set squares, and drawing free body diagrams.

b) Sharp pencils rather than ball point pens should be used for drawing.

c) Frames and force tables can be constructed from laboratory equipment or in school shops.

d) The principle of moments can be investigated by suspending a metre stick and moving masses attached to it to different positions along its length.

e) When determining the balance point of a metre stick with masses hanging from it, different student groups can be given different combinations of positions for the masses.

Core Unit 7: Fluids Time: 13 h

The world is surrounded by fluids which include gases and liquids. Fluids have properties that are unique from solids. An understanding of the characteristics of fluids has given rise to many applications that exploit these unique properties. Examples include weather balloons, hydraulic presses, internal combustion engines, the design of aircraft and automobiles.

The purpose of this unit is to increase the students' ability to analyze and predict the behaviour of fluids at rest and in motion.

This unit may be divided into topics such as the following:

- Density of fluids
- Hydrostatic pressure
- Gauge pressure
- Archimedes' principle
- Streamlined flow
- Bernoulli's principle

1. Objectives

Attitudes. Students will be encouraged to develop:

a) a curiosity about the effects created by fluids that are stationary and in motion (3d, 3e, 3g, 4a, 4b);

b) an appreciation for the contributions of Archimedes, Bernoulli, and Pascal to scientific development (3c, 3d, 3f, 3g, 4c);

c) an appreciation of the importance of fluids and their properties (3a, 4).

Skills. Students will have the opportunity to develop skill in:

a) measuring, calculating and recording the mass, volume, density, and pressure of various liquids (2a-2h, 2k);

b) using a manometer to measure the relative hydrostatic pressures of fluids (2b, 2c);

c) mathematically solving problems involving pressure in a fluid using the formula $p = \rho gh$ (2b);

d) using a hydrometer to measure the relative density of a liquid (2h);

e) reading a mercury or aneroid barometer (2f);

f) recording and interpreting experimental results during the study of Archimedes' principle (2g);

g) drawing free body diagrams of forces acting on objects completely or partly submerged in a fluid (2g);

h) observing and drawing diagrams to illustrate examples of streamlined and nonstreamlined fluid flow (2i);

i) solving simple mathematical problems involving Pascal's law, guage and absolute pressure, and Archimedes' principle (2d, 2e, 2g);

j) recording, and interpreting the data for the pressure in the three regions of a Venturi tube (2k);

Knowledge. Students will be expected to:

a) recall mass, area, volume, density, and the SI units and symbols used to record them (2a, 2g, 2h);

b) define pressure as force per unit area measured in the SI unit, pascals (Pa), and having (P) as the SI unit symbol (2e, 2f);

c) explain the creation of pressure in situations involving liquids and gases at rest or in motion (2b, 2d, 2f, 2i, 2k);

d) explain how density and height affect hydrostatic pressure (2b);

e) state the relationship(s) among density, depth (height) and pressure in a fluid which is, pressure = density x force of gravity x height (2b);

f) describe the relationship between pressure and area and shape of a container (2c);

g) explain how a barometer functions (2f);

h) give examples that illustrate Pascal's law and recognize and explain situations that involve its use such as a fire hose under pressure or a inner tube (2d);

i) differentiate among atmospheric pressure, gauge pressure, and absolute pressure, and state the relationship among them which is, absolute pressure = atmospheric pressure + gauge pressure (2e);

j) draw a diagram and explain the functioning of a hydraulic lever (2d);

k) state Archimedes' principle and use it to explain buoyant effects in fluids (2g);

l) differentiate between streamlined and nonstreamlined fluid flow (2i);

m) identify factors which determine the drag created on an object moving through a fluid (2j);

n) explain the variations in pressure seen in various locations of a Venturi tube as water flows through it (2k);

o) state Bernoulli's principle and explain applications of it (2k);

2. Student Activities

Students are to:

*a) measure the volume and mass of a given sample of a liquid and calculate its density (6a, 6b);

b) conduct an experiment to i) compare the pressures at a specific height in fluids of different densities; ii) compare the pressure in a fluid at different heights of the column; iii) determine the effect of the height of a column of fluid on the pressure near the bottom (6a, 6b, 8a, 8b, 8e);

c) experimentally determine the relationship between pressure and shape of container with all other variables controlled;

d) experimentally verify Pascal's law (6c, 8b, 8c, 8f, 8g);

e) measure and record several gauge pressures, and calculate the absolute pressure (6c, 8b, 8c);

*f) read the air pressure from a mercury or aneroid barometer for at least three consecutive days (6b, 8b);

*g) verify Archimedes' principle for suspended and floating objects (8b);

*h) determine the relative densities of several liquids using a hydrometer (6a, 6b, 8b);

*i) investigate and draw diagrams of streamlined (laminar) and nonstreamlined (turbulent) flow (8i);

j) compare the times for beads of different shape, size and mass to fall through columns of liquids of differing densities (6b, 8b);

k) measure the relative pressure in a Venturi tube with a streamlined flow of water, down stream from the constriction, at the constriction, and upstream from the constriction (8b, 8c, 8h).

*See the subsection entitled "Student Activities" on page 7.

3. Applications

a) Fluids are the medium for transportation in a wide variety of systems, from intracellular systems to intercontinental flight, (e.g., dissolved constituents enter and leave cells, blood floats in serum, fish swim in water, birds fly in air, humans transport sound from mouth to ear through the medium of air).

b) Fluids act as lubricants to reduce friction (e.g., synovial fluid in joints, saliva in the throat, oil in hinges, grease between automobile parts).

c) Hydrometers are used to determine the quality of various fluids by measuring the relative density (e.g., strength of battery acid or anti-freeze).

d) Archimedes' principle helps to explain the operation of submarines and hot air or weather balloons.

e) Aircraft and motor vehicles are designed to reduce the drag of the air in order to increase fuel efficiency.

f) One universal application of Pascal's law is in a hydraulic press.

g) A carburetor on a car and a spray atomizer employ Bernoulli's principle.

4. Societal Implications

a) Many people die yearly due to high blood pressure. The earning power of families is greatly depleted and it costs the general public in social welfare and health care costs.

b) Variations in atmospheric presure contributes to different kinds of weather.

c) Pascal's law led to the development of many hydraulic devices which reduced the need for much manual labour and permitted technological advances not possible before.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) ability to carry out laboratory activities;

b) practical tests;

c) laboratory reports.

6. Safety Considerations

a) The use of mercury should be avoided.

b) Students should be informed regarding the particular hazards of each fluid used.

c) Students should be cautioned regarding the pressure differentials that can develop in some laboratory equipment such as the hydraulic press.

7. Possible Extensions

Some students might:

a) design, carry out and record observations in an experiment to determine the rate of flow of a fluid;

b) observe and analyse several experimental examples of applications of Bernoulli's principle such as carburetor, or Venturi meters (used in instrumentation and research);

c) examine the structure of various balls used in sports and analyse the reasons for the designs (size, shape, surface features such as bumps or pocks). Examples can include a golfball, football, basketball, volleyball, tennis ball, squash ball, croquet ball, pool ball, billiard ball, or beach ball;

d) design siphons for various functions (e.g., an Archimedes screw for water elevation, a fountain pen for ink uptake, a gasoline

siphon for negligent travellers, an aquarium siphon for cleaning the tank);

e) visit an autoshop, garage or auto assembly line and have a mechanic demonstrate and explain the operation of pistons, the measurement of oil pressure and tire pressure, the operation of hydraulic lifts on trucks and farm machinery;

f) invite a cardiologist to speak on pressure in blood vessels of the body and demonstrate measurement of blood pressure;

g) visit a steam museum, agricultural or other vehicle museum and report on the pressures and mechanisms involved in operating reciprocating and non reciprocating steam engines;

h) use a pressure cooker to cook various foods and note the safety valve and timing variations needed for different foods (e.g., meat, fish, vegetables, fruits). Analyse the interrelationship between pressure and temperature in cooking foods;

i) derive and apply Torricelli's principle;

j) investigate the equipment and instructions required for SCUBA diving because of the pressure under the water;

k) design and build a wind tunnel.

8. Some Teaching Suggestions

a) The value of understanding how and why pressure changes occur and what effects these changes have should be emphasized. It is the pressure differential that matters.

b) Before operating instruments or devices in this unit the structures should be examined and predictions made regarding what will occur.

c) Gauges and devices foreign to the students should be brought in and students should have the opporunity to predict how they

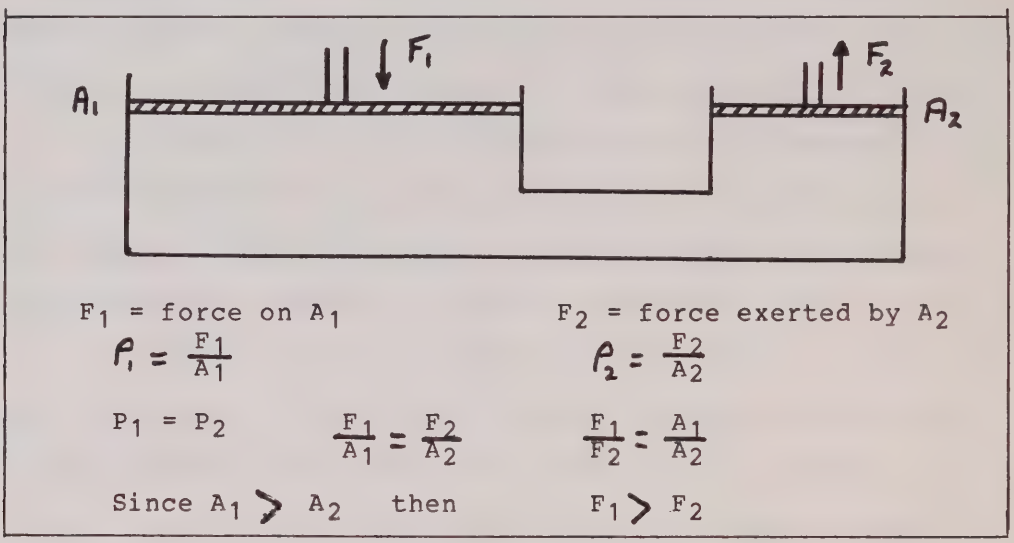
might be used.

d) Guest speakers from industry and medicine can be invited to the classroom.

e) Students should construct their own manometers to be used in the activities.

f) Pascal's law can be investigated by the operation of a simple hydraulic lever.

g)



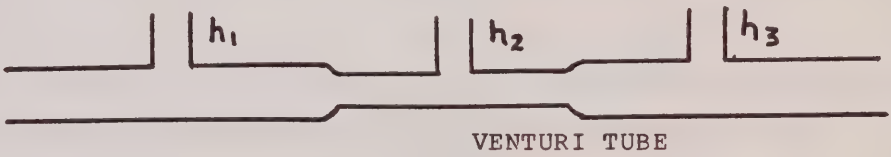
F_1 = force on A_1 F_2 = force exerted by A_2

$P_1 = \frac{F_1}{A_1}$ $P_2 = \frac{F_2}{A_2}$

$P_1 = P_2$ $\frac{F_1}{A_1} = \frac{F_2}{A_2}$ $\frac{F_1}{F_2} = \frac{A_1}{A_2}$

Since $A_1 > A_2$ then $F_1 > F_2$

h)



VENTURI TUBE

the height of the fluid (h_1) = the height of the fluid (h_3)
the height of the fluid (h_2) < the height of the fluid in (h_1) or (h_3)

i) A two-metre long plastic tube of 10 mm diameter and water with analine dye added can be used to demonstrate laminar and turbulent flow. Constant-velocity water flow should be done first followed by accelerated water flow. A ripple tank can also be adapted to this purpose.

Technological Science, Grade 12, General Level

Core Unit 8: Machines Time: 7 h

Machines form a vital part of today's society. High-tech machinery still incorporates simple machines as components. In this unit students will become aware that machines make work easier, save time, and are used to facilitate motion. The combination of simple machines may make a machine that appears complex, but the complex machine can be broken down into its simple components.

This unit may be divided into topics such as the following:

- Simple machines
- Mechanical advantages - ideal and actual
- Pulley systems
- Efficiency
- Compound machines

. Objectives

Attitudes. Students will be encouraged to develop:

a) an appreciation that machines help to make work easier (3b, 3d, 3f, 4b, 4c);

b) an appreciation that high-tech robotics still incorporate the concepts of simple machines (3e, 4b).

Skills. Students will have the opportunity to develop skill in:

a) classifying machines (2a, 2b);

b) rearranging components of machines (e.g., pulleys) to obtain optimum efficiency (2c, 2d);

c) calculating ideal mechanical advantage, actual mechanical advantage, and efficiency of a machine (2a-2c);

d) measuring and recording forces and distances (2a-2c);

Knowledge. Students will be expected to:

a) identify the six simple machines (2a);

b) identify where the load and effort are applied for each of the six simple machines (2a-2c);

c) explain the value of machines to industry and workers (2);

d) define ideal mechanical advantage, actual mechanical advantage, and efficiency (2a-2c);

e) explain why the efficiency of machines is variable (2);

f) state the relationship between the ideal mechanical advantage and the number of strands in a pulley system (2c);

g) determine the ideal mechanical advantage of a compound machine (2c, 2d).

2. Student Activities

Students are to:

*a) experimentally determine the ideal mechanical advantage for each of the following: wheel and axle, inclined plane, wedge, screw jack or C-clamp (6, 8a, 8b, 8d, 8h);

*b) determine the ideal and actual mechanical advantage for a first class lever for given load position but differnt effort positions, and compare the efficiency in each case (8a-8d);

c) assemble pulley systems to give ideal mechanical advantages from 1 to 5 and determine the actual mechanical advantage, and the efficiency of each (6, 8a-8d, 8h);

*See the subsection entitled "Student Activities" on page 7.

d) design and build a gear train to produce i) high speed of rotation ii) power. Determine the ideal mechanical advantage in each case (6, 8a-8d, 8h).

3. Applications

a) Levers and gear trains that have an ideal mechanical advantage of one are useful in instrumentation (e.g., Bourdon tube gauges, gas meters and clocks).

b) Levers are widely used in construction equipment (e.g,, mobile cranes and backhoes).

c) Small worm and wheel mechanisms are useful for tuning guitars, rack and pinion steering, and in a hand auger.

d) Motor driven machinery utilizes gear or belt drives (e.g., rototiller).

e) Machines are so fundamental that they still have a place in space technology (e.g., the Canadarm).

f) Gear trains are used in multispeed racing bicycles.

4. Societal Implications

a) The energy supply problem has brought about the need for maximizing the efficiency of machinery.

b) High-tech machinery improves quality of workmanship and reduces the number of tedious jobs.

c) Machines, by cutting down on human energy required in the home or work place, allow increased opportunities to participate in and enjoy leisure time activities but also contribute to a decrease in physical conditioning of many people.

d) The trend to manufacturing quieter machinery is sometimes hindered because the public associates noise with power.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) setting up machines as directed;

b) ability to perform the experiments and complete the calculations required.

6. Safety Considerations

Students should be warned that a small effort can cause great distress to a finger or hand at the output end of a machine (e.g., a screw vice).

7. Possible Extensions

Some students might:

a) collect pictures from periodicals and prepare a display of industrial or domestic machinery that use simple machines as components (e.g., pictures of construction equipment that use machines studied in class);

b) determine the efficiency of a commercial machine or mechanism;

c) use "mechano" type sets to build a variety of compound machines and analyse their characteristics;

d) investigate the human body as a machine.

8. Some Teaching Suggestions

a) Appropriate tables and graphs should be incorporated into laboratory reports.

b) All students should have "hands on" experience with the machines.

c) The experiments should be kept simple.

d) The accurate reading of instruments should be encouraged.

e) Students should be encouraged to bring in examples of simple machines used in the home (e.g., kitchen gadgets, tools).

f) Museums of technology, bicycle shops, auto shops, dockyards can be visited to observe a variety of machines.

g) Copies of appropriate periodicals should be available for student use.

h) To save time, various groups can each build one of the machines required in the different activities, then the groups can rotate through different stations to record measurements or each group can work with one machine and report their results to the class for a general analysis.

Optional Unit 1: Materials Time: 13 h

Various ages of civilization have been classified according to the materials of their artifacts such as the Stone Age, the Bronze Age, and the Iron Age. The dreams of emperors, architects, and silversmiths have often come true as they dealt with different materials.

The purpose of this unit is to have the students gain an understanding of the properties and behaviours of materials that often enable them to be used in specific applications. Whether it is the nose cone of a space vehicle, the concrete for a foundation, or the ball of an artificial hip joint, the materials used determine the serviceability and characteristics of the structures.

This unit may be divided into topics such as the following:

- Crystalline solids
- Cohesion and adhesion
- Stress and strain - extension and compression
- Density
- Hardness
- Corrosion
- Absorption of water
- Heat and electrical conductivity

. Objectives

Attitudes. Students will be encouraged to develop:

a) a respect for the architects and engineers of the past, and their contribution to our culture (3a, 4b, 4c);

b) an appreciation of the relationship between the properties of a material and its uses (3a-3c, 3g, 4c);

c) curiosity about the composition of structures and materials around them (3b, 3c, 3e, 3g, 4b);

d) open-mindedness to the use of new materials in construction and manufacturing (3a, 3c, 3g, 4c);

e) objectivity in analyzing materials and structures (3b, 3c, 3g, 4b, 4c);

f) an appreciation of the impact that the development of many new synthetic materials has had (3a, 3c-3e, 3g, 4a, 4c, 4d).

Skills. Students will have the opportunity to develop skill in:

a) using a microscope (2a);

b) drawing sketches to record observations (2a);

c) measuring forces with a spring scale (2c-2e);

d) measuring distances and masses with appropriate measuring equipment (2e-2h, 2k);

e) calculating areas, stress, strain, density, Young's modulus, and volume of a solid (2e-2g);

f) preparing samples of Plaster of Paris and cement for use in the activities (2h, 2i);

g) following directions and recording observations for various activities (2);

h) drawing conclusions about properties and behaviour of different materials (2b-2f, 2h-2l).

Knowledge. Students will be expected to:

a) describe properties common to all solids (2g);

b) distinguish between crystalline and amorphous solids and give

examples of each (2a);

c) define cohesion, adhesion, density, stress, strain, and elasticity (2b-2h);

d) state the formulas for calculating Young's modulus and density (2e, 2g);

e) explain briefly the reasons for cohesion and adhesion of materials (2b-2d);

f) describe how a metal can be protected from corrosion (2j);

g) describe the effect of too much and too little water in cement (2i);

h) explain how a geologist can determine which of two substances is harder (2h);

i) identify three substances that are good conductors of heat and two that are poor (2l);

j) identify two substances that are good electrical conductors and two that can act as insulators (2l);

k) explain the meaning of the terms ductility and maleability (2a).

2. Student Activities

Students are to:

*2) observe and draw diagrams of samples of various crystalline solids as seen under a microscope, observe and describe the crystallization of salol under a microscope or on an overhead projector (8a);

b) examine and compare the cohesion between different flat surfaces including glass plates and plastic sheets (8b);

c) compare the adhesion of different types of adhesive tapes to different surfaces. The tape may be attached to a secured

*See the subsection entitled "Student Activities" on page 7.

surface and a spring scale used to record the force needed to remove the tape (6b, 8c, 8d);

d) glue two pieces of wood or other material together with different commercial adhesive products, and after the glue has set the recommended time, try to separate them using a spring scale to record the force needed (6b, 8c, 8d);

e) determine the stress and strain on a given sample of wire or elastic fabric and calculate Young's modulus (6a, 8c);

*f) compare the stress and strain in compressing different samples of polyurethane foam, and also use samples of one type with different surface areas (6a, 8c);

*g) identify a sample of metal or metal shot, by determining its density (8c);

h) examine the hardness of various materials such as Plaster of Paris, cement, or different kinds of wood by dropping on each, from a specific height, a vertically guided, hard pointed bit. The shape and depth of the indentation produced should be described (6a, 8c, 8d);

*i) prepare small samples of cement using correct and incorrect amounts of water, and after allowing each sample equal setting time as prescribed for the correct mixture, compare their characteristics (8d);

j) investigate the effect of oxygen, water and salt on the corrosion of various metals (8c, 8d);

k) compare the ability of various substances such as wood, brick and cement to absorb water by comparing the mass before and after the sample is immersed in water for varying periods of time (8c, 8d);

*See the subsection entitled "Student Activities" on page 7.

l) compare the ability of different substances to conduct heat and electricity (6c, 8c).

Applications

a) The challenge of technology is to use materials wisely and to identify and fabricate imaginative and useful materials.

b) Many new adhesives have been developed such as "Crazy Glue" which are extremely strong and require only a small quantity to be effective.

c) Synthetic fibres are used in the production of fabrics for many purposes. These fabrics exhibit elastic properties, are light, and may be used in the clothing, furniture, and drapery industries.

d) The development of the space program has contributed many new materials for use in other fields.

e) Refinements in materials production has benefitted the advances in microtechnology needed in the computer and electronics industries.

f) Bridges, buildings and vehicles can become unpredictably weaker due to stress reversals over a period of time and with changes in the seasons.

g) Synthetic materials are replacing metal parts on the exterior of automobiles.

Societal Implications

a) Our natural resources are limited. Efficient use will not only save money but also provide for the future.

b) The strengths of materials change with the seasons and time. To ensure safety, regular structural inspections of bridges,

buildings, and aircraft should be done.

c) New materials and innovative uses of presently known materials can improve the quality of structures in our environment such as using modern prestressed concrete in place of wood and steel.

d) Materials research and development is a growing area for career opportunities.

5. Evaluation of Student Achievement

At least 50 per cent of the term mark for this unit is to be based on students':

a) ability to carry out laboratory work and complete individual laboratory reports;

b) records of observations made during activities.

6. Safety Considerations

a) When testing stress, strain, and hardness of materials, the eyes should always be protected with safety goggles.

b) During adhesion experiments springs and other materials can spring back or snap and damage eyes and other body parts. Students should be warned of these possible dangers.

c) Heating materials can result in severe burns from the heat and from the materials. Students should be protectively dressed and have suitable implements to grasp hot materials.

7. Possible Extensions

Some students might:

a) investigate and report on the Mohs hardness scale.

b) participate in a field trip to local university or community college to observe various material testing, such as hardness,

tensile strength, elasticity, and toughness;

c) invite an engineer or architect as a guest speaker on careers, strength of materials, alloys, or another relevant topic;

d) visit local steel, aluminum, nickel, or other metal industries to observe first hand treatment of pure and alloyed metals;

e) research or test the strength of hollow (tubular) versus solid metal (cylinders) materials under tension, compression, and torsion;

f) research nondestructive testing of materials such as ultrasonic testing for cracks in landing gear of airplanes, bonded strain gauges and polarized testing of transparent materials;

g) view sampls of materials studied such as cement and wood under a microscope.

8. Some Teaching Suggestions

a) Students could have an opportunity to view materials studied under a stereo microscope if they are available.

b) When dealing with adhesion "static cling" should be discussed.

c) Time can be used efficiently in several activities if different groups work with different materials then share their findings to allow general conclusions to be drawn.

d) Students should have the opportunity to design experimental procedures and select materals for study.

Optional Unit 2: Locally Designed Unit

Time: 13 h

This unit is to be designed at the local level as desired. It can be used to introduce a new area or topic of science not described in this guideline or to incorporate additional objectives that will expand a previous part or parts of the course. Examples of new areas or topics that might be considered include:

Careers in technology
Machines
Energy
Basic electronics

This unit may provide an excellent opportunity for students to engage in independent study on a topic in the technology area that is of particular interest and that is approved, monitored, and evaluated by the teacher. Students may work individually or in small groups. Care should be taken to not allow the work to overlap with subject matter in other science courses that the students are likely to take. The unit could be started after the students have had some experiences in the laboratory and are well aware of accident prevention. If a series of short topics are considered they may be fitted into the course schedule from time to time throughout the semester or year.

It is expected that the local design of this unit will incorporate components similar to those adopted in the core units, namely, objectives, student activities, applications, and societal implications. An outline of the unit is to be included with the school's course of study and kept on file so that it is available to interested students and parents.

Appendix A: The Table of Contents of Part 1

Preface

Introduction

Part A: Goals and Aims

1. The Value and Purpose of Science Education

2. The Goals of Education and the Role of Science

3. The Aims of the Science Curriculum

    3.1 The Nature of science
    3.2 Scientific Literary
    3.3 Curriculum Emphases - Blending Curricular Aims with Content

Part B: Science Program Framework

4. Science Courses

    4.1 Exploration and Specialization
    4.2 Levels of Difficulty: Basic, General, and Advanced
    4.3 Science Courses and Credits
    4.4 Units of Study Within Each Course
    4.5 Preferred Routes Through the Secondary School Science Program

5. Teaching Policy

    5.1 Content and Process
    5.2 Components in Each Unit of Study
    5.3 Teaching Policy for All Science Units
    5.4 Time Allocations for Each Unit
    5.5 Locally Designed Units
    5.6 The Placement and Naming of Local Science Courses
    5.7 Overall Policy for Science Courses

Part C: Special Features of the Science Program

6. Considering the Science Student

    6.1 The Image of the Successful Science Student
    6.2 Program Adaptations for Exceptional Students
    6.3 Individualized Instruction
    6.4 Life Management Skills
    6.5 Employment Awareness
    6.6 Sex Equity
    6.7 Multiculturalism

7. Language in Science

    7.1 Language Skills
    7.2 Language Assignments and Evaluation

8. Measurement

8.1 Estimation
8.2 Metric Units and Physical Quantities
8.3 Metric Editorial Practice
8.4 Accuracy and Precision
8.5 Formats in Solutions to Problems

9. Safety

9.1 Safety in the Laboratory
9.2 Some Recommended Safety Procedures
9.3 Animal and Plant Care

10. Values in Science Education

10.1 Morals/Values in Science Courses
10.2 Handling Sensitive Issues

Part D: Implementation

11. Curriculum Planning and Staff Development

11.1 Policy Planning at the Board Level
11.2 Program Planning at the School Level
11.3 Course Planning at the Teacher Level
11.4 School Board Curriculum Documents
11.5 Staff Development

12. Resources

12.1 Science Laboratories and Equipment
12.2 Library Resource Centres
12.3 Textbooks and Learning Materials
12.4 Calculators
12.5 Computers
12.6 The Scientific Community

13. Modes of Delivery

13.1 Bilivel and Multigrade Classes
13.2 Co-operative Education
13.3 Program Packages
13.4 Adult Education
13.5 Independent Learning Centre
13.6 Specialized Science Schools

14. Evaluation

14.1 Evaluating Guideline Implementation Progress
14.2 Evaluating Student Achievement
14.3 Self-Evaluation of Teacher Performance
14.4 Evaluation of Program Effectivness

Appendix A: Science Courses and Their Course Codes
Appendix B: Physical Quantities
Appendix C: Metric Editorial Practice
Appendix D: Some Poisonous Plants
Appendix E: Some OAIP Instrument Types and Learning Domains

Appendix B: Science Courses and Their Course Codes

The secondary school guideline courses in science authorized under this document have the following course codes.

Science, Grade 9, Basic Level	SNC 1B
Science, Grade 9, General Level	SNC 1G
Science, Grade 9, Advanced Level	SNC 1A
Science, Grade 10, Basic Level	SNC 2B
Environmental Science, Grade 10, General Level	SEN 2G
Science, Grade 10, General Level	SNC 2G
Environmental Science, Grade 10, Advanced Level	SEN 2A
Science, Grade 10, Advanced Level	SNC 2A
Science, Grade 11, Basic Level	SNC 3B
Applied Biology, Grade 11, General Level	SBA 3G
Applied Chemistry, Grade 11, General Level	SCA 3G
Environmental Science, Grade 11, General Level	SEN 3G
Biology, Grade 11, Advanced Level	SBI 3A
Chemistry, Grade 11, Advanced Level	SCH 3A
Science, Grade 12, Basic Level	SNC 4B
Applied Physics, Grade 12, General Level	SPA 4G
Environmental Science, Grade 12, General Level	SEN 4G
Technological Science, Grade 12, General Level	STE 4G
Environmental Science, Grade 12, Advanced Level	SEN 4A
Geology, Grade 12, Advanced Level	SGE 4A
Physics, Grade 12, Advanced Level	SPH 4A
Biology, OAC	SBI OA
Chemistry, OAC	SCH OA
Physics, OAC	SPH OA
Science in Society, OAC	SSO OA

---

*General rules governing science course codes:

- All science course codes begin with S.
- SNC identifies a course which only has the name "Science".
- Where one word other than "science" describes the course, the first two letters of that word follow the S.
  E.g., SBI means "Science, Biology" or simply "Biology".
  SEN means "Science, Environmental" or "Environmental Science".
- Where two words other than "science" describe the course, the initial letters of those words are used.
  E.g., SCA means "Science, Chemistry, Applied" or simply "Applied Chemistry".
- The fourth character in the course code, 1, 2, 3, 4, or 0, represents Grade 9, 10, 11, 12, or an OAC respectively.
- The fifth character represents the level of difficulty: B for basic, G for general, or A for advanced.

R.W.B. JACKSON LIBRARY
3 0005 03009319 2

R.W.B. JACKSON LIBRARY
3 0005 03009319 2